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STEAM ENGINE PRACTICE AND DESIGN

Construction and Design of Modern Types of Cross Heads

The cross head, or motion block, as it is sometimes called, is one of the most important mechanical parts of the steam engine. It must, with the aid of the guides, keep the end of the piston rod from bending out of the line of the axis of the cylinder when the strain on the connecting rod produces such a tendency; it must have ample wearing surface so that the

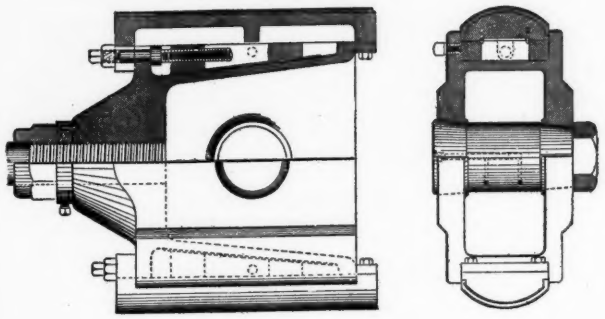


Fig. 1.

pressure due to the transmission of the pressure on the piston shall not be excessive per unit of surface; it must have some connection to the connecting rod and at the same time allow the rod to move in a plane parallel to the axis of the cylinder; the wrist pin must be of sufficient size to withstand the load upon it; and arrangements must be made for taking up the wear on the moving surfaces so that these functions will be continuous.

As the cross head and guides are complements of each other and must fit together, the shape and number of the guides will depend upon the arrangement of the cross head. The principal function of the guides is that of keeping the cross head from moving in any direction other than that parallel to the axis of the cylinder. The plane of the guides must therefore also be truly parallel to the axis of the cylinder and as this matter is of prime importance, many methods are used which will make this a certainty. The principal method used is to have the cylinder and guide in one piece so that after the cylinder is bored, the guides are bored with the same bar concentric with the cylinder. This insures a common axis for the cylinder and guides.

Like the piston, the proportions of the cross head are largely a matter of experience rather than of calculation. The guides may number one, two or four, depending upon the design of the cross head, but they are always made massive so that they will not deflect. When a horizontal engine "throws over," all of the pressure and wear comes upon the lower slide. If the engine "throws under," all the pressure and wear comes upon the upper slide. Since lubricants flow over the lower guide more easily than the upper and since it is easier to resist the strain on the lower guide, as it usually rests on the bed plate, it is customary to cause engines having motion in one direction only, to "throw over" rather than under.

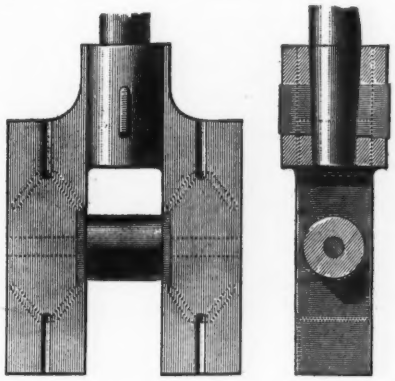


Fig. 2.

The greatest pressure upon a slide occurs when the piston is near the middle of its stroke, there being none when the crank is at its dead points. The total pressure on the guide depends upon the total steam pressure on the piston and the ratio of the length of the connecting rod to the radius of the crank. This ratio varies between four and eight, so that in general

terms it may be stated that when the length of the connecting rod is four times the radius of the crank, one-fourth the total steam pressure comes upon the guides when the cross head is near its middle position, and when the connecting rod is eight times longer than the radius of the crank, the maximum pressure on the guides is only one-eighth of the total pressure on the piston. Since the pressure per square inch on the guides

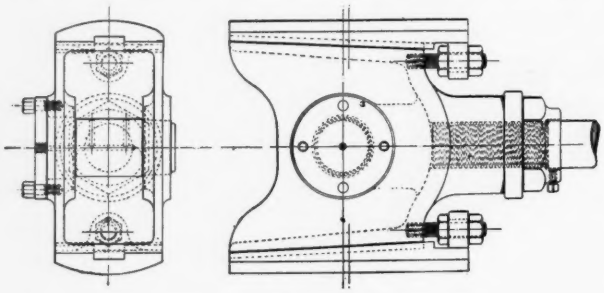


Fig. 3.

should not at any time exceed 100 pounds per square inch, the minimum area of the guides can be obtained by dividing the maximum total pressure on the guides by 100.

When but one guide is used, the cross head is made in two forms. In one form the cross head is made to embrace the rectangular guide on all four sides, as shown in Fig. 4. In this form, the guide is a rectangular bar and the cross head pin must be far enough above it so that when the connecting rod has its widest swing it will clear it. This form is used extensively in locomotive practice with the plane of the guide however above the cross head pin.

The other form of single guide is known as the slipper form and is illustrated in Fig. 9. The engine in this case is usually designed to turn in one direction only and the guide is a flat plane surface with suitable edges to prevent any side motion.

When two guides are used, as is usual in most stationary engines, the vertical cross head is adopted; that is, one guided in the plane in which the connecting rod oscillates. With this arrangement the guides must be far enough apart to clear the connecting rod when it makes its widest angle near half stroke.

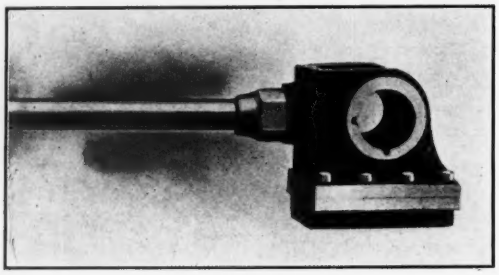


Fig. 4.

When such cross heads are used, the guides are either flat and plane, they may have two flat surfaces inclined to each other or they may be cylindrical. The two latter methods are those most widely adopted. On account of its advantage and ease of alignment, the bored guide is now used more than any other form.

The wear on the contact surface between the cross head and guides is taken up by shoes, which may be of cast iron, bronze or some non-friction metal.

The shoes are adjusted by means of inclined surfaces moved by means of keys, by means of eccentric bolts or by means of liners, each of which is illustrated in the accompanying figures.

The four guide cross head is not often used in stationary practice although it is a favorite design for locomotives. It makes a light cross head and gives large rubbing surfaces and is often made without gibs because, owing to the small pressure per square inch, the two surfaces are supposed to be kept separated by a film of oil. The Porter-Allen engine uses four guides, the cross head of which is shown in Fig. 2.

To distribute the oil over the wearing surfaces, the shoes usually have grooves cut in them so that the contact surfaces not only hold the oil but distribute it sideways.

The cross head pin or wrist pin is made of such a size that it will resist maximum pressure upon the piston which may come upon it. It is often made equal to the crank pin in size; in other cases, its diameter is made 1.25 times the diameter of the connecting rod and its length 1.8 times the diameter of the connecting rod. Some authorities give the rule that the maximum pressure upon the cross head pin should never exceed 1200 pounds per square inch. It is usual to make the pin fast in the cross head and have the connecting rod swing on it but often in marine practice this is reversed. The wrist pin is

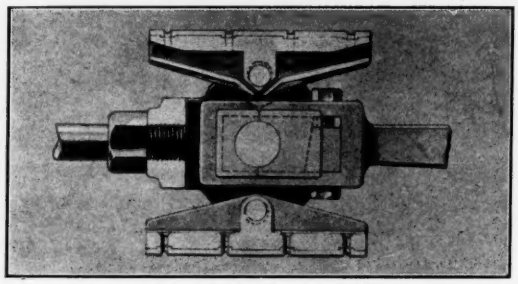


Fig. 5.

often made hollow so that oil will run through it and out to the contact surface by means of a radial hole.

The various cross heads described below are illustrative of stationary practice.

The cross head used on the Murray-Corliss engine is shown in Fig. 1. The shoes are turned to fit the bored guides and have a bearing the entire length of the cross head. Besides an adjusting screw and lock nut, two other screws are provided to prevent the possibility of their becoming loose, but which will permit of their removal for examination, scraping or re-babbitting. A very heavy neck is used in this design, into which the piston rod is screwed. The rod is prevented from turning when once in place by means of a nut and locking collar placed between the nut and cross head.

A cross head which has four wearing surfaces is illustrated in Fig. 2 and is used on the Porter-Allen high-speed engine. The large, flat surfaces bear upon the guides, the guide and guide bar faces being finished by scraping to true planes. The wrist pin is made of steel fitted in the middle of cross head. The piston rod in small engines is screwed into the cross head and held in place by a lock nut but in larger sizes the piston rod fits into a tapered hole in the cross head and is held fast by a tapered transverse key.

The St. Louis Corliss cross head, Fig. 3, is bored to fit the guides, the shoes being tapered and lined with anti-friction

metal and fitted to the cross head with tongue and groove. Adjustment is made by means of studs and nuts at the ends of the shoes; the shoes can be taken out and rebabbitted without removing the cross head. The cross head pin is located at the centre of the cross head and is ground to a taper fit and held in place by two cap screws. The cross head is threaded to receive the piston rod which is held from turning by a jam nut.

The cross head of the Reeves engine is of the box design, as shown in Fig. 4. It embraces the guide, which is of the single bar pattern, on all sides, the wearing surfaces being faced with anti-friction metal. The piston rod is screwed into the cross head and held in place by a jam nut. The cross head pin is made of steel and is fastened to the cross head with taper fit and held in place by both key and bolt. The bar guide is made of iron and scraped to surface plate. The guides can be removed from the frame and can be adjusted by means of liners.

The cross head of the McEwen engine, Fig. 5, is somewhat different from the ordinary design inasmuch as the shoes are held in position by eccentric bolts. When it is necessary to adjust the shoes for wear, the nut is loosened and the eccentric bolt turned to give the proper adjustment, after which the

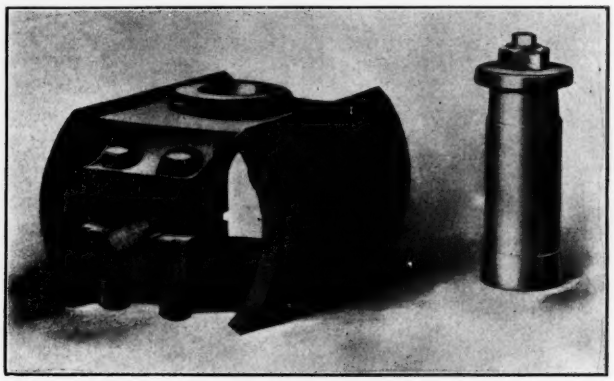


Fig. 6.

nut is tightened, when it will remain in that position. As the shoes swivel on the eccentric bolts they necessarily must have a full bearing on the guides. The cross head pin is of steel and fitted to the cross head with a long taper on each side. The shoes are faced with babbitt. The guides are bored and afterwards scraped. Both upper and lower guides, as well as the cross head pin, are oiled from the top. The oil is wiped off by the upper shoe, is caught in oil grooves extending across the face of the shoe and led through oil holes at each end of grooves to inside of upper shoe. A funnel-shaped hole in strap leads the oil to the cross head pin; from there it drops to lower shoe and then through holes in this shoe to lower bearing.

The Phoenix cross head is shown in Fig. 6. It works in bored guides and is provided with adjustable shoes. The cross head pin is made of forged steel ground to fit. The piston rod is screwed into a split bushing which, after its position is adjusted, is clamped by two bolts with lock nuts. The bolts are also prevented from turning by the use of set screws.

The cross head of the Ideal engine is shown in Fig. 7. It is of the box form with phosphor-bronze slides attached at top and bottom. Adjustment of the wear is made by putting a thin liner between the cross head and lower slide, the upper slide with these engines never requiring adjustment as all the engines run "over"; this positive adjustment being claimed to be superior to the ordinary wedge arrangement. The guides are bored and the slides turned to fit. They are lubricated by the oil thrown from the crank discs. The upper slide wipes off a portion of the oil thrown on the top guide and carries it

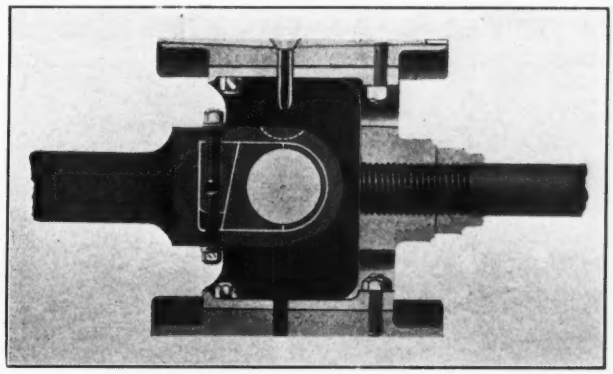


Fig. 7.

through channels cut in the slipper for this purpose to a vertical opening over the cross head pin. The oil flows down through this passage on to the connecting rod stub, which has a cavity milled in its top with a splash guard back of it for catching the oil dropping from above. From this oil cavity or cup, holes lead down to the pin.

The cross head used on the Harris-Corliss engine is shown in Fig. 8. The bored guide is not used in this design, two flat surfaces forming an obtuse angle being used instead. Adjustment is made by concealed wedges operated by fore and aft adjusting bolts. The wrist pin is made of steel, tapered and ground to fit. It is secured by means of bolts and a steel plate on the front side of the cross head and is so arranged that the pin can be turned in the cross head to correct any tendency to wear flat and which is removed when the connecting rod is to be disconnected. The piston rod is screwed into the cross head and held in place by a lock nut. The bearing surfaces of the slides are lined with babbitt. The cross head used on the

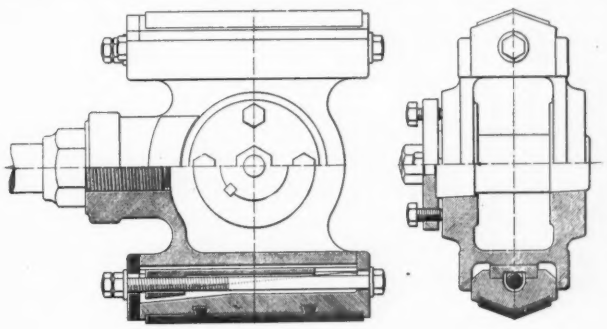


Fig. 8.

Fulton-Corliss is very similar in principle to that shown in Fig. 8, except that it has bored guides instead of straight surfaces.

A type of cross head that is often used on small engines is shown in Fig. 9, which represents the cross head used on the Frost engine. It differs from the cross head shown in Fig. 4, where the cross head embraces the guide; in this case, the guides embrace the cross head. The Frost cross head is made out of cast iron, the slides being planed, the top and bottom

bearings being filled with babbitt metal to insure a good wearing surface. The cross head pin is made of three different diameters which fit the holes in the cross head and the connecting rod.

The cross head used on the Fishkill-Corliss engine, shown in Fig. 10, is somewhat different in design from any shown above, especially in the way the gibs or slippers are adjusted.

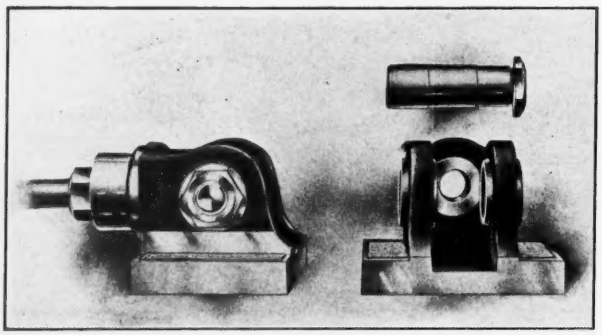


Fig. 9.

Instead of the usual wedge arrangement, this cross head is fitted with four adjusting keys which hold them firmly in place. The slides, which are flat surfaces fitted with babbitt metal, can be removed by taking out the keys and the wear can be taken up by screwing the nut on the end of the key, the adjustment being permanently secured with the lock nut. The cross head pin is made of hammered steel drawn to its permanent position by a large nut. The piston rod is fitted to a taper hole in the hub of the cross head and secured in place by a steel cross key.

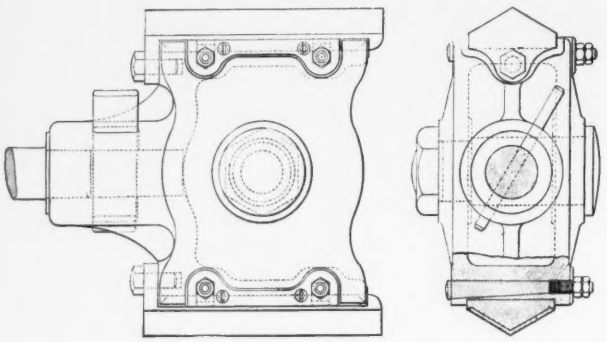


Fig. 10.

The different cross heads shown above are taken from only a few of the many engines in use to-day but with few exceptions they represent the principal forms of cross heads found in modern steam engine practice.

Are Steam Jackets Economical?

By G. B. Cooley.

In using steam jackets on the cylinder of steam engines, it seems to me that in avoiding one evil, we have another to contend with, which is just as bad but not quite so much in evidence. To get at the true condition of affairs as they really are, let us follow the steam first through the unjacketed cylinder and then through the one with the steam jacket.

The steam on entering the cylinder at the beginning of the stroke loses considerable of its heat in raising the temperature of the head, walls and piston to the temperature of its own. This loss of heat is represented by more or less condensed steam in the form of water and is almost a total loss so far as its ability to do work is concerned. As fresh surfaces are uncovered by the moving piston, more condensation takes place and continues until after cut-off occurs. As the steam expands after cut-off, the pressure and temperature decrease in the same proportion and no more steam is condensed.

The reason that condensation ceases with the expansion of steam is this. The walls, cylinder head and piston have been heated to a temperature equal to the steam at the beginning of the stroke, and as the temperature of the steam begins to fall, due to the expansion, they give off some of their heat and re-evaporation begins. Most of this condensed steam is re-evaporated and the terminal pressure is raised, as shown by the indicator card. After release takes place, the exhaust steam, being cooler than the cylinder walls, extracts heat from them on the return stroke. It will be noticed that the whole loss in the unjacketed cylinder is at the beginning of the stroke or up to the point of cut-off. After cut-off no more steam is condensed and what has been condensed is re-evaporated, thus raising the terminal pressure.

With a steam jacketed cylinder, the steam on entering the cylinder will not be condensed, as the head and cylinder will have the same temperature as the incoming steam. Condensation will not take place, as in the former case, the heat to prevent it being supplied by the jacket. As expansion begins the pressure is lowered but the temperature of the steam is maintained nearly constant by the heat being supplied to it through the cylinder walls. Steam at a temperature higher than that corresponding to its pressure is superheated, which is the case in a jacketed cylinder. The only economy in superheated steam is up to the point of cut-off and if superheated beyond that point, it represents an actual loss, as the only saving is due to the prevention of initial condensation. On the opening of the exhaust, this steam passes out and the remaining steam absorbs heat from the cylinder walls the whole length of the stroke.

The absorption of heat from the cylinder walls on the return stroke is a total loss of heat, as the temperature must be raised at the expense of the heat in the jacket. What gain can there be in a steam jacket when the heat supplied by it is wasted by superheating after cut-off? If the heat supplied by the jacket was to cease at cut-off, there would be a saving, due to the prevention of initial condensation. All the heat supplied to the cylinder is taken from the steam in the jacket and if there is no condensation in the cylinder, there is in the jacket, which is a loss just the same.

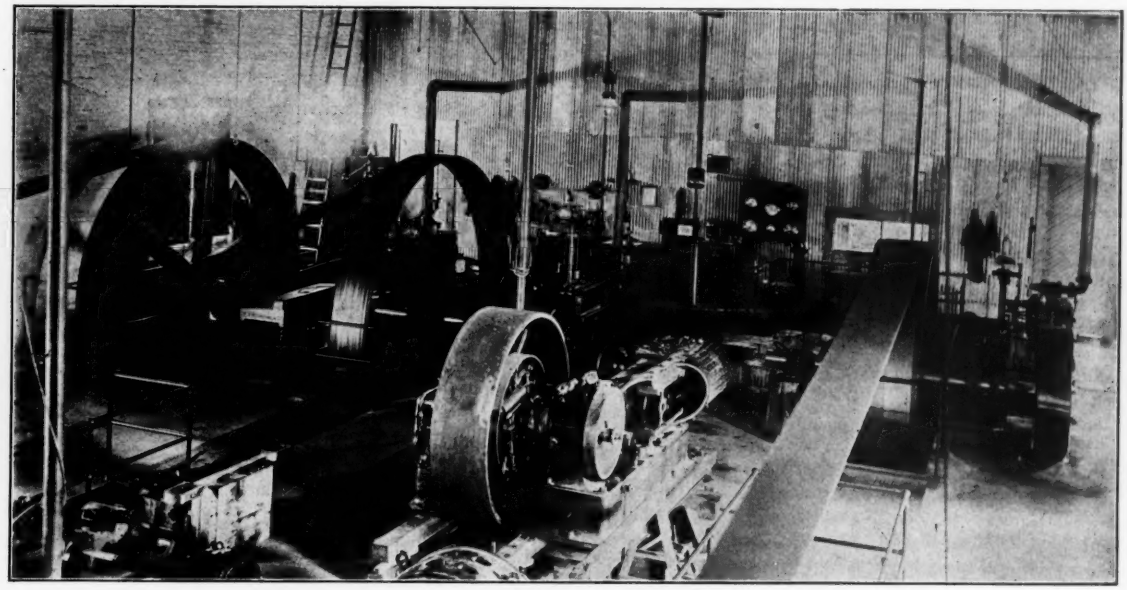
A cylinder with a good covering of some non-conducting material will effect more of a saving than the most perfect working steam jacket in operation. The loss from heating the exhaust steam on the return stroke is considerable and, in my opinion, greater than the initial condensation.

The lap of a Corliss valve is the amount by which the valve closes the port when the eccentric and wrist-plate are in their central positions.

A CALIFORNIA ELECTRIC PLANT

Plant of the Monterey Gas and Electric Co., at Monterey

In many parts of the country, gas and electric companies are finding it to their advantage to consolidate; in other places, gas companies are installing electric light plants of their own operated by gas engines or steam engines; and in still other places, waterworks companies are now consolidated with light and gas companies, the pumps being operated by electric power or gas engines. Power is distributed by electric current and the lighting being done by both electricity and gas. A company which represents a combination of the gas, electric and water industries is the Monterey County Gas and Electric Co. which is a successor to the Salinas City Light and Power Co., the Salinas Water, Light and Power Co., and the Monterey Electric Light and Development Co.



Engine Room of the Monterey Gas and Electric Co., Monterey, Cal.

The gas, electric and street railway plants supplying service to Monterey, New Monterey, and Pacific Grove, owned by this company, are located at Monterey. The steam electric plant at Monterey is installed in a corrugated iron building, 52 feet wide and 143 feet long, the engine room of which is shown in the accompanying illustration, the gas works being located in the rear and having a length of 66 feet.

The boiler plant includes three Murray return tubular boilers of 150 horse power, each operating at a pressure of 150 pounds per square inch. These boilers are supplied with a fuel of crude oil which is pumped from a tank 24 feet wide and 7 feet deep, the oil being pumped directly into this tank from the oil tank cars placed on the siding opposite the power house. In order to easily pump the oil from the car tanks, steam is passed into heating coils of the tank car and the viscosity of the oil being thus reduced, two Stillwell-Bierce pumps force the oil to the storage tank through a meter, one pump being held in reserve. The oil used has a gravity of about 15 degrees Beaume and costs about 76 cents per barrel of 42 gallons.

In the power house, there are four engines varying from 150 to 250 horse power capacity of the Buckeye, Wetherill-Corliss, Nagle-Corliss and Lane and Bodley-Corliss types. The Buckeye operates at 175 revolutions per minute, the three Corliss engines at 94, 108 and 98 revolutions per minute respectively. These engines are connected by belts to two-phase alternators and direct-current machines of from 150 to 200 kilowatts capacity each. The alternators supply a two-phase current of 2300 volts and the direct-current machines supply a continuous current of 550 volts for railway service. A motor generator set is also installed, consisting of a 550 volt railway generator of 150 kilowatts capacity directly driven by a revolving field synchronous motor with a rating of 162 kilowatts, operating at a speed of 720 revolutions per minute. Between the motor and generator is a 22-inch pulley with a 16-inch face, belted to the 200 horse power Buckeye engine fly-wheel. By this arrangement both the units of the motor generator may be operated as direct and alternating-current dynamos and affords a link by means of which the two-phase load may be coupled with the railway load, allowing a day alternating-current service to be maintained in connection with the railway load with a maximum efficiency of operation.

The waterworks and steam electric plant at Salinas includes pumps driven by gas engines and single-phase alternators operating at a pressure of 1040 volts driven by a Columbian-Corliss engine. This engine is so arranged that it can be made to operate a triplex pump in case of necessity caused by a breakdown. In this plant there is also a modern gas plant supplying water gas made from crude oil.

The gas works at Monterey is equipped with apparatus in-

stalled by the California Light and Fuel Co. and includes a scrubber and scrubber-condenser, as well as a superheater, washer and generator. At the Monterey gas works salt water is used for gas making, while at Salinas, fresh water is employed. During one month of 1904, more than half a million cubic feet of gas were made, the average amount of oil used being a trifle over 210 gallons per day, the average gas made being 17,000 cubic feet per day, this being an average of about 12 gallons of oil per 1000 cubic feet of gas made.

THE STEAM TURBINE PROBLEM

Comparison of the Cost and Performance of Reciprocating Engines and Steam Turbines

By Paul Bigelow.

It has been frequently stated by the untechnical, and occasionally by the alleged technical, that the days of the reciprocating engines are passed or passing, but such assumption is evidently ill founded.

It will be several years before all locomotives are relegated to the scrap heap and it will probably be longer before the thousands of small belted or direct-connected steam engines built, or to be built, for such plants as cotton gins, mills, office buildings, weave sheds, wood-working plants, stamp mills, etc., are superseded by steam turbines. Rolling mills and metal working plants will, no doubt, also stick to reciprocating engines for a few years more.

Assuming that all the claims made by the manufacturers of steam turbines, as to excellence of material, workmanship and design, are true, (though these are too liberal concessions and are daily shown to be ill founded), let us compare the two sorts of installation as to cost and results. In this comparison it is assumed that 1000 kilowatts will have to be generated. Absolute accuracy of cost in dollars and cents is not claimed but the estimates are as fair for one side as they are for the other:

The Reciprocating Engine.	The Steam Turbine.
1. For the Reciprocating Set we *may* have a direct connected, belted or rope drive, or	1. For the Turbo-Generator we *must* have a direct connected set and
2. Alternating or direct current generator.	2. Alternating current generator. *Note.*—As at present offered, steam turbines are of necessity built for such rapid rates of revolutions that all belted or rope drive sets are cut out of the question, unless a system of reducing gearing is used—this is obviously undesirable. For the same reason, they are unsuitable for driving commutating electric machinery.
3. Cost of the set, about $45,000 (if direct-connected) delivered on purchaser's foundations.	3. Cost of the set, about $45,000, delivered on purchaser's foundation.
4. Or at the rate of, say, 10 cents per pound.	4. Or at the rate of about 50 cents per pound. *Note.*—This price per pound seems excessive for the class of work under consideration. It has been hinted that such prices must be secured by the manufacturers that in case their guarantees of efficiencies are not demonstrated, there will still be enough profit in the contract to enable them to install reciprocating engines in place of the turbines without much loss. The difference between first cost of a turbine and its value as junk is very considerable. Whatever the sum, it will have to be charged up to depreciation account sooner or later.
5. Cubic space occupied, say, about 9000.	5. Cubic space occupied, say, about 5000.
6. Cost of foundations for engine set and condenser, $3000.	6. Cost of foundations for turbo-generator and condenser, at $1.15 per kilowatt equals $11 50.
7. Cost of boilers to produce dry, saturated steam, at 125 pounds pressure, $10,000.	7. Cost of boilers to produce a working pressure of 175 pounds.—See item 8.
8. No superheater necessary.	8. With superheaters for say 200 degrees, $13,000. *Note.*—It must be borne in mind that superheat is secured only by allowing the steam intimate contact with metal surfaces heated to the point of destruction, and which are subject to rapid oxidation due to the presence of the steam itself; the good results obtained being in proportion to the deterioration of the apparatus producing them.
9. Cost of jet condenser to produce 26-inch vacuum, (same capacity), with water at as high as 90 degrees, $800. Space occupied, 270 cubic feet. *Note.*—For 26-inch vacuum, any sort of condenser may be used, and even with condensing water as high as 85 degrees or 90 degrees, the vacuum is not lost. Ratio of condensing water, 30 to 1.	9. Cost of suitable condenser to produce 28-inch vacuum, with condensing water at 70 degrees, $8,000. Space occupied, 700 cubic feet. *Note.*—The guarantees of economy of turbines are most frequently made on a basis of 28-inch vacuum, and the purchaser has to furnish it. A surface condenser only is adapted for this high vacuum; and again, if the condensing water is over 70 degrees, it is not possible to obtain 28 inches by any means. Ratio of condensing water 60 to 1.

10. Cost of pipe, covering, valves and fittings for 125 pounds, $10,000.

11. Total cost of items considered, $68,800.

12. Total cubic space occupied, 9200.

ECONOMIES GUARANTEED UNDER CONDITIONS ENUMERATED IN PARAGRAPHS 7 AND 9.

13. One electrical horse power on 16 pounds of water per hour.

14. If we insist on same conditions of operation as specified for the turbo set, the economy becomes 14 pounds at rated load.

Note.—If we expend the same amount for high efficiency (?) auxiliary apparatus (boilers, condensers, covering, etc.) that we contemplate for the turbine, as well as $1850 more for the greater foundation necessary, we can save at least 1.3 pounds of water per electrical horse power per hour more than the best the turbine can do when new; or on the same basis of coal cost, about 7 cents per hour at full load (the load and conditions of operation being quite flexible), still not a very wise investment, but twice as wise as the turbo proposition.

15. The efficiency of a reciprocating engine will remain almost constant to 20 per cent. above or below rated load,—then the economy falls off more rapidly on the under loads than on the over loads—about 15 per cent. at 50 per cent. over load, and about 30 per cent. at 50 per cent. under load.

16. If, in the reciprocating set, the 26-inch vacuum is entirely lost, the efficiency is about 20 pounds at full load and 26 pounds at half load.

17. No superheater was considered in the specifications of the reciprocating installation. A few degrees superheat, say, 10 degrees to 50 degrees would be a benefit, however.

18. Noise. Very much less than in the turbine.

10. Cost of pipe, covering, valves and fittings for 175 pounds and superheat, at $14.00 per kilowatt equals $14,000.

11. Total cost of items considered, $81,150.

12. Total cubic space occupied, 5700.

ECONOMIES GUARANTEED UNDER CONDITIONS ENUMERATED IN PARAGRAPHS 7, 8 AND 9.

13. One electrical horse power on 15.3 pounds of water per hour at rated load.

Note.—For the turbo outfit, we have to expend $12,350 more than for the reciprocating engine installation. We save .7 of a pound of coal per electrical horse power hour, or if coal is $1.00 per ton, the saving is about 3.5 cents each hour that the set is in operation at its most favorable *load* and the *most favorable* conditions, (the conditions are rigid, if the load is flexible)—not a very wise investment surely, being less than 1 per cent. of the extra prime cost.

14. Assume same conditions of operation as specified for the reciprocating set, and the economy becomes about 17.25 pounds at rated load.

15. The efficiency curve of a steam turbine under varying loads, (other conditions of operation remaining ideal and constant) is flatter, probably, than in a reciprocating engine,—it being claimed that a change of 50 per cent. in load above or below nominal produces an increase of only 12 per cent. in fuel consumption.

16. If, however, the vacuum above mentioned (28 inches) is reduced or lost, both the efficiency and capacity of the turbo set falls rapidly away, the economy being about 35 pounds at full load and 48 pounds at half load. With atmospheric exhaust it is necessary to use three times as much coal at half load as it is at full load with 28-inch vacuum. Under a back pressure there is no efficiency whatever.

17. If the superheater fails, or for any reason saturated steam is supplied the turbine, not only does the economy fall off at the rate of about 1 per cent. for each 3 degrees loss of superheat, but the erosion of the blades and moving vanes becomes a serious consideration. If the economy at 200 degrees superheat is 15.3, with saturated steam the economy would be 25.4. If the claim of the builders is true that for each 40 degrees of superheat the capacity of the turbine is doubted, the converse must be also true, viz.: For each 40 degrees loss of superheat, the capacity must be cut in half. Therefore, if the set is rated at 1000 kilowatts under the specification, then with saturated steam the capacity would be only 200 kilowatts. It is doubtful if the pumps could keep enough water in the boilers or the firemen would be sufficiently agile in opening the dampers and shoveling coal to keep things moving under this condition.

18. Noise. This is difficult of comparison; however, as a result of careful estimates, it would seem that the ratio is about 1 to 2.5 in favor of the reciprocating engine; under unfavorable conditions it may be ten times greater.

Among the items above, it will be noticed that items 1, 2, 4, 7, 8, 9, 10, 11, 13, 14 16, 17 and 18 are in favor of the reciprocating engine and items 5, 6, 12 and 15 are in favor of the steam turbine, while item 3 is the same for both types of prime movers. That is, the reciprocating engine admits of a more flexible connection in the utilization of its power; it costs less per pound; total cost of installation is less; its efficiency is greater except under ideal conditions and it is very much less noisy. The steam turbine does not occupy so much space; its cost of foundation is less and it is claimed to be more economical for varying loads.

To bear any sort of comparison with a reciprocating engine plant, it would appear therefore that in a turbo-generator installation every component part of the lay-out must be always in the highest state of repair and efficiency—a condition as yet seldom obtainable in commercial practice.

SOME MORE ABOUT PISTONS

By E. M. Paul.

After reading the very interesting article in the March number of "The Practical Engineer," the thought came to me that some readers might be interested in a more thorough discussion of the different forms of pistons in common use, and as you had just written me a letter saying that I could write about anything I thought would interest "the boys," I concluded to try the effect of this subject on you.

The common box piston with snap rings is so largely in use that but little comment is necessary. Its faults and its virtues are so well known that to attempt to describe them in detail would be superfluous. About all that it has to recommend it is its cheapness and the ease with which it may be repaired or replaced when occasion demands, and its freedom from complicating parts which are likely to become misplaced and cause trouble. At first thought one would be inclined to think that a piston of this type would seldom or never be used in the better class of engines, but it is no less a fact that even in large engines, operating under high pressures, such pistons are frequently met with.

This being the fact, one is led to inquire the reason why they are used, more especially as their faults are so evident. Perhaps a little investigation of the merits and demerits of the other types of piston may help solve the problem.

Broadly dividing the several styles of pistons into two classes, the box, or snap-ring type, and that which has a follower plate, either with or without a bull ring, let us turn for a little to the latter class and discuss their characteristics. If we examine the illustrations of this style of piston, shown in the March number of this paper, we shall discover that they all have a certain similarity in construction and design. The object has been in each case to provide means for centering the piston in the cylinder and thus keep the piston rod truly central to the bore of the stuffing box, and also to provide some means for keeping the packing ring in contact with the walls of the cylinder so that no steam may leak past it during any part of the stroke. All this is very desirable, but just as soon as there is any attempt to introduce means of adjustment, just so soon complication of parts begins and the consequent liability to get out of order and cause trouble of greater or less seriousness. The trouble may be nothing more than the necessity for frequent adjustment or inspection, or it may cause the wrecking of the engine.

Still speaking broadly of the follower type, rather than any particular make of piston, as it is a general principle that applies to them all, there is a liability of the follower plate bolts either working loose and coming out, or else crystallizing and the heads breaking off; in either case doing damage. I have seen many an engine wrecked by both these causes.

The various styles shown in the illustrations referred to all have either bolts or studs by means of which the bull rings or the packing rings are adjusted. In either case there is the liability of these screws working out of adjustment, sometimes causing the piston to get out of centre or sometimes even causing the rings to "seize" on the cylinder walls and cut. The builders are quite as well aware of these faults as is the engineer who is in charge of the engine, and many attempts have been and are being made, to overcome this difficulty, some of which are quite successful, and others of which are complete failures. In all cases there is some means provided for locking the adjusting screws, usually with a jamb nut, more rarely with a set screw. The follower plate bolts are nearly always fitted so closely that there is not supposed to be any danger of their working out. This is open to the objection that strains are set up in the metal of the bolts each time they are removed that tend to crystallize them and, after a time, through this and other causes which I have not the space to discuss now, the bolts become so brittle that they break like glass when subjected to strain.

Whether all these attempts to safeguard the piston have been successful or not is best answered by the number of accidents that take place from the causes named. That the number of these accidents is very large, every engine builder in the country knows from sad experience, and they will all tell you that if some means could be devised that would fulfill all the requirements, almost any price would be paid for the right to use it. The ingenuity of an army of designers is being taxed to the utmost to devise a piston that shall be absolutely safe, adjustable and cheap. The elimination of even one of the factors of danger present in this type of piston is of immense importance and means many thousands of dollars saving to the builder who can devise it.

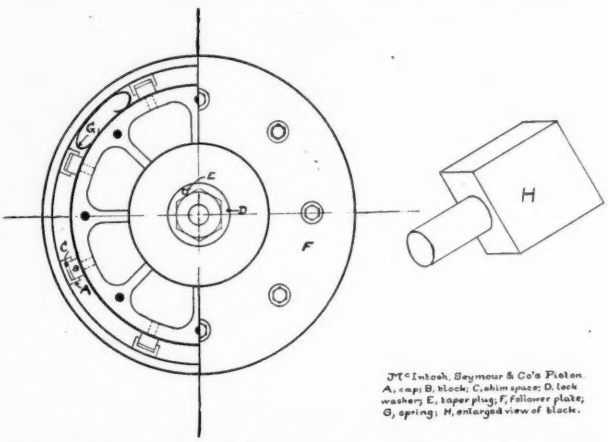
There is a piston made by McIntosh, Seymour & Co., which is somewhat different from the usual style of this type and which embodies some points that particularly commend it to the engineer from its safety and ease of adjustment. Special pistons are sometimes built to meet certain conditions, but they are usually built regardless of expense and are not ordinarily used in the standard engine sold by their makers, as is this piston to which I refer.

By an examination of the sketch, it will be seen that a number of blocks B, the projecting portions of which are rectangular in section, shown at H, are arranged about the circumference of the spider. These blocks have a round stem which is driven into a slightly smaller hole in the spider. They are provided with caps of steel which are the same width as the packing ring and fit closely over the end of each block. When the follower plate F is in position, these caps cannot move except in a direction parallel to the axis of the blocks, or in other words, in or out from the centre of the piston. There are provided shim pieces of thin steel of various thicknesses which are of the same width as the caps and of a length which will allow them to be inserted between the end of the block and its surmounting cap. In manufacturing these pistons, they are first turned and then the holes for the stems of the blocks are drilled, after which the blocks are driven into place and the piston returned to the lathe and the ends of the blocks turned off to the proper length, thus making them true to the piston. The caps for the blocks are made of metal of exactly the same thickness and are bent to conform to the

proper radius, so that the assembled blocks, caps and piston are all truly concentric.

From this it will be seen that it is a very easy matter to centre the piston in the cylinder, all that is necessary being to introduce an equal number of shims of the same thickness in the space C under each of the caps A. In practice it is usual to allow about one thirty-second of an inch play between the ring and the spider when the piston is all essembled. In this way the ring has a chance to expand and spring together a small amount, while the piston proper is still practically central in the cylinder.

No steam is allowed to enter the space below the ring, the elasticity of the springs G back of the packing ring being relied on entirely to hold the ring in contact with the cylinder walls. The joint in the ring is made steam tight by a bronze piece which is very carefully fitted so that it has a bearing on both sides of the ends of the spring as well as the bottom, with which it is kept in contact by an oval spring back of it. The rod is turned taper and is ground to fit. It is pulled into place by means of the large nut shown. The nut is kept from turning by means of a split washer D which fits on a square formed on the under side of the nut, the outside of this washer fitting



McIntosh, Seymour & Co's Piston. A, caps; B, block; C, shim space; D, lock washer; E, taper plug; F, follower plate; G, spring; H, enlarged view of block.

very exactly into a recess bored into the follower plate. After the nut is screwed up as tightly as possible, the taper plug E in the split washer is screwed down hard, thus expanding it against the sides of the recess in which it fits and so preventing any danger of the nut coming off.

This firm also build quite a large number of their low-pressure cylinder pistons of steel, conical in shape and having the same means of ring adjustment as those already described. The steel pistons do not differ in construction from these except in the fact that no follower plate bolts are used, the piston rod nut being sufficient to hold the follower plate without any other bolts. In this style of piston there is nothing which can come loose and do any damage, no complication of parts; there is ease of adjustment, and when the adjustment is once made it is permanent.

As will be seen, these pistons have no bull ring and but one packing ring, which is made sufficiently wide to prevent leakage. The packing ring has two shallow grooves turned in it which serve as a receptacle for oil and water and form an additional means of rendering the ring steam tight, just exactly as is done in the piston of an indicator.

Another defect in the common way of providing means of adjusting the packing or bull rings, is in the fact that the head of a bolt or a nut presents but a very small area of bearing at the point of contact, and in practice it is quite common to see the rings worn very badly at these points. In the piston under discussion this is entirely obviated, as the surface in contact with the ring is of the same width as itself and may be made as long as is necessary. Still another disadvantage of the screw arrangement is that in a small piston, the room is so contracted that it is almost impossible to use a common wrench to adjust the screws and nuts. This is particularly disadvantageous when the engine is hot, and the job of adjusting such a piston in a hurry is by no means a pleasant one.

That the wearing of the packing or bull ring at the point of contact with its adjusting screw is of importance, is shown by long experience with this type of adjustment. In the course of my twenty-five years' experience as an engineer, I have seen many a ring that was worn almost entirely through. One of the worst cases that I call to mind at the present moment was that of an engine whose piston was provided with a bull ring which was adjusted by means of studs on which were two nuts which were screwed out to contact with the ring and then locked by jambing them together. This engine was under the care of a very careful man who inspected the piston at short intervals and on one occasion when taken down it was found that the nuts had worked loose on the studs and the play had been so great that several holes were worn in the bull ring, the largest of which would hold about half a glass of water. The studs had worn so that some of them were almost entirely gone and a number of the nuts looked very much like finger rings, being worn perfectly smooth both inside aud out. Several of the nuts were entirely worn through and only some small pieces remained.

From the foregoing it will be seen that there is a wide field for the designer of the ideal piston. Very much has been done, but there remains an equal amount to accomplish. Even in the best pistons there is still left an element of weakness that might be removed, as for instance, the follower plate bolts in the McIntosh piston. If it might be possible to build a piston at once easily accessible, strong and with no loose parts which by any possibility could come loose, cheap in construction and not costly to repair, then the ideal would have been attained, but up to the present time no one has been able to fulfill all these conditions.

As the weight of a piston increases, so also does the difficulty of preventing rapid wear in the cylinder of the engine. With the horizontal engine this wear is a very important question, and practically determines the life of the engine.

In the vertical style of engine, the need of supporting the piston is not present, but the question of keeping the packing ring in contact with the cylinder is just as important as ever.

From this short discussion, we may draw some conclusions in a general way regarding the merits and demerits of the two types of piston under discussion. With the box type, there is the advantage of cheapness and lack of complicating parts, with the disadvantages of rapid wear of the rings and cylinder, due to admitting steam back of the rings, inaccessibility in case of accident to the rings, it being necessary to remove the piston from the cross head, lack of means for keeping the rod central in the cylinder, and a great many other faults that will occur to those who have such pistons under their charge. In the follower plate type there are the advantages of easy access, means for keeping the rod central, adjustability of the ring,

it being possible to provide a constant tension back of it to hold it in contact with the cylinder, which tension may be as small as possible for the work required and thus reducing wear, and a cheaper cost of repairing except in case of the total wrecking of the piston. Against all these advantages must be placed the disadvantages of complication of parts with the liability to get out of adjustment and cause serious accidents.

Seeing all this, I cannot wonder that builders still cling to the old box piston even though they see its faults as clearly as does the engineer. They know that it wears out a cylinder in much less time than a piston should, is prone to break its rings and in general act as if some malignant spirit had taken up its abode in it, but they also know that it is not in the habit of wrecking an engine through failure of any of its parts except in very rare instances, is easy and cheap to make, and in short,—there is nothing that is at once so simple and so sure as the box piston when the service required is extremely hard. In the light of my own experience with the follower plate piston, I can hardly blame them for having this opinion.

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The Hydraulic Plant on the Canal of Jonage.

By Frank C. Perkins.

The hydro-electric power plant located on the Canal of Jonage, France, possesses more than passing interest, both in its equipment and method of construction. Of a total of nearly half a million cubic yards of masonry used in the construction work of the Canal of Jonage, fully three-fourths is of concrete. The reason for this was due to the fact that stone would have to be brought on cars a distance of nearly 20 miles, while large quantities of gravel and sand were found in the excavation. Mechanical mixing of the cement, sand and gravel was employed, resulting in a concrete which is said to be of a superior quality.

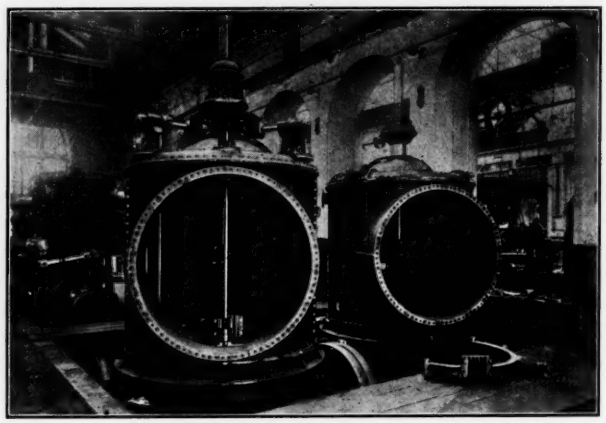
The accompanying illustration shows two of the turbines installed in the power plant, each having a capacity of 1250 horse power. The hydraulic plant consists of 16 turbo-alternators, eight of which have a capacity of 1350 horse power each and the other eight a capacity of 1250 horse power each, while three other turbines have been installed for the exciter dynamos, each having a capacity of 250 horse power.

The turbines are of the reaction inward radial flow type, with vertical shafts, and were designed for a head of from 35 to 40 feet with a flow of from 2770 gallons to 3200 gallons per second, the speed of the turbines being 120 revolutions per minute. As shown in the illustration, the turbines are enclosed in casings to which the water is brought by horizontal flumes, and the weight of the shaft and wheel, as well as that of the armature of the alternator, is carried by water pressure on a piston controlled by a system of automatic gates. The casing is 8 feet under water at high water, being carried on the masonry by a ring base which rests at the mean level between low and high water.

The exciter turbines, as well as the main turbines, are supplied with automatic governors which are said to regulate very closely. The exciter turbines operate at a head of from 36 to 40 feet with a speed of 250 revolutions per minute and a flow of 580 to 660 gallons of water per second.

The exciter dynamos are of the 4 pole type and supply a total current of 1533 amperes at a pressure of 120 volts. The 16 alternators driven by the main turbines are of the three-phase type and each have a capacity of 1100 kilowatts, while the exciters above mentioned each have an output of 174 kilowatts. The main alternators each generate a current of 200 amperes when operating at a speed of 120 revolutions per minute, the pressure being 3500 volts. These machines are of the vertical revolving field type with fixed armatures. They have an efficiency of 94 per cent. with a power factor of .74 and an efficiency of 95.2 per cent. with a power factor of 1.

The power generated at this hydro-electric plant is transmitted over a line consisting of 12 feeders to a number of villages, as well as the City of Lyons. At the various points the current is transformed to a pressure of 110 volts at substations for supplying the secondary system of distribution. The current is extensively used for both arc and incandescent lighting



Two of the 1250 H. P. Turbines installed at the Jonage Power Plant

as well as for power purposes, three-phase induction motors being extensively employed. The rates charged by the Lyons Power Company of the Rhone for its several thousand consumers ranges from 10 cents to 16 cents per kilowatt hour according to whether the electrical energy is utilized in the city buildings, factories, cafés, stores or apartments. A discount of from 1 to 10 per cent. is allowed as the consumption of current increases from $20 per month to $300 per month. It is stated that the receipts during the year 1904 were more than half a million dollars.

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Suggestions for Starting Up an Ice Plant.

At this season of the year, the thoughts of many engineers are turned toward the refrigerating portion of their plant, which will have to be started after the long rest of the winter, and for this reason we have been requested by many of our readers to give some suggestions in reference to the starting up of an ice plant after a period of idleness.

The usual apparatus used in an ice plant are the boiler, feed pump, steam engine, compressor, oil trap for ammonia, condenser, liquid ammonia receiver, oil separator, purifier, steam condenser, hot skimmer, reboiler, cooling coil, filters, cold water reservoir, can filler, freezing tank, hoist and thawing apparatus.

The steam generated in the boiler is first used to drive the steam engine and then passes through the exhaust pipe to the steam purifier and grease extractor, where any oil or other lubricating material used in the cylinder of the engine likely to be detrimental to the ice is removed. The steam then passes

into the steam condenser, in which the steam is condensed, and passes to the skimming tank, where any oil that may have passed through the steam purifier is removed. The water resulting from the condensed steam passes to the reboiler, at the bottom of which is placed a coil. This coil is supplied with a small quantity of live steam from the boiler, by means of which the water is kept boiling and the air contained in it is expelled; and, as the steam which is used to drive the engine may not be sufficient to make water for the full quantity of ice, live steam is introduced to the steam condenser to supply the deficiency.

From the reboiler, the water passes to the cooling coils and from thence to the filters. These filters are usually furnished in duplicate so that one may be shut off and cleaned while the other is running. From the filters the water passes to the cold storage tank where the distilled water is cooled to almost freezing temperature and stored until again used. From the storage tank the distilled water is filled into the cans placed in the freezing tank by means of an automatic can filler.

The freezing tank is made of iron or steel and contains the direct expansion freezing coils distributed throughout the tank. These coils are submerged in brine, which acts as a medium of contact only, the ammonia evaporating in the freezing coils extracts the heat from the brine, which again absorbs the heat from the water in the cans, thereby freezing it. The hoisting apparatus is usually strong and easily movable, so that one man can deliver a can of ice from any part of the tank to the thawing apparatus. The thawing apparatus consists of either a bath of warm water into which the cans are placed, or an automatic sprinkling and dumping apparatus into which the cans are placed and when loosened discharged into the storage rooms. This in general outlines the course of the steam in a can plant and the transformation of the water into steam and then into ice.

In the refrigerating part of the system the complete cycle of operation is respectively the compressor, the fore cooler, the oil separator, the condenser, the liquid ammonia storage tank and the expansion coil and in the starting up of a plant, it is this part which gives the most trouble. Each particular type of machine working on the compression system has certain distinctive and characteristic features and so far as they are concerned will require special care and adjustment but there are certain rules which can be laid down for all systems working on this principle.

When the plant was shut down there was probably some ammonia gas left in the compressor and before starting up this should be blown out through the purge valve at the top of the compressor but care should be taken that none of the ammonia gas is inhaled. If much of it is present, it can be neutralized by burning sulphur which will not perhaps be any more agreeable but will be far less irritating and less dangerous to the health. When sulphur is burned in the presence of ammonia gas it gives off white fumes, which fact is often taken advantage of in detecting and locating leaks in any part of the ammonia system.

The head of the compressor should then be lifted off and then the safety head removed. This is usually more or less of a difficult job owing to the ammonia fumes which are encountered and provision should be made for lifting it without having to come too close to the cylinder. The piston and rod can then be lifted out by unscrewing the rod from the cross head. Owing to the complication of most pistons in an ammonia compression machine this is a difficult job and for that reason many machines are furnished with a bushing or guide bored to the size of the compressor bore and fitted on the outside to the diameter of the dome. This bushing guides the packing rings of the piston out of and into the cylinder. The stuffing box should first be loosened, after which if possible a rope should be fastened to some projecting portion of the piston, usually the valve which is in the piston, which will facilitate the withdrawing of the heavy piston and rod.

The piston rings should then be examined to see that they are not worn or that they have spring enough and that they fit the groove of the piston properly. If not, then the rings must be either peened or new rings put on. The piston rod should be examined for scars, rough surfaces or out of round, and if any defect is found, it should be remedied as it is very hard to maintain a tight stuffing box under those conditions. If the rod is turned down, it is probable that the stuffing box will have to be bushed, as it should never be much over 1-32 inch larger than the diameter of the rod.

If the machine has had much use the preceding summer, then both the suction and discharge valves should be ground so as to be sure they seat properly, as they have much to do with the efficiency of a machine.

If the valve stems of the suction and discharge valves are made to act as plungers working in dash pots, as is done in some makes of compressors, they should be examined for wear and if any is found it is probable that they will have to be replaced with new ones, as they are difficult to bush and unless they are a good fit, the valves will be noisy.

While the piston is out of the cylinder, the rotundity of the bore should be examined, especially in a horizontal machine, and if badly worn, it should be rebored and the piston refitted. Having been assured that everything is in good working condition, the piston can be inserted in the cylinder and the rod connected to the cross head.

In screwing up the piston rod, great care should be taken to see that the piston has the right clearance on the compression end. If too little is allowed there is danger of damaging the machine and if too much the efficiency of compression is lowered. The closer the piston moves to the safety head the more gas is expelled each stroke. A clearance of about 1-64 of an inch is what is generally allowed, or even less, if conditions permit. One way to determine this is to put the piston on the top centre and by laying a straight edge across the compressor cylinder the desired clearance can be had by screwing the piston in the cross head. The safety head and springs are then put on and the compressor head screwed on, making sure that the gasket, which is usually of lead, is in good condition.

The cross head, cross head shoes, cross head pin, crank pin and main bearings should also be examined and rebabbitted or scraped and trued up where necessary in the same usual manner that is done in all steam engines. The inspection and care of the steam end of the compressor should be nearly the same as mentioned for the ammonia end.

The packing of the piston rod should be done after all the other parts are adjusted and must be done with a great deal of care, as it is very important that there shall be no leak there.

(To be continued.)

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The Practical Engineer is devoted to the economical generation and utilization of power for the industries.

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Indicating High-Speed Engines.

Ever since the construction of the first Porter-Allen engine, which marked the beginning of the manufacture and use of high-speed engines, most of the improvements made in the indicator, as first used by Watt and improved by McNaught and Richards, have been mainly with the object of adapting it for use with high speeds. Although the refinement along the lines of light moving parts, small diameter of drum and improved drum motions seems to have reached the limit, there is still opportunity for inaccuracies to creep in when taking a card from a high-speed engine.

When taking a card from a low-speed engine, the effect of momentum on the moving parts and indicator string may be negligible but, with engines running at high speed, these things are very liable to distort the indicator card, from which erroneous conclusions are likely to be drawn unless these difficulties are foreseen and corrected.

In all cases it is important that the friction of the indicator piston should be kept as small as possible and especially so in high-speed work where the undulations in the pencil point caused by a jumpy piston will distort the card beyond recognition of its true form. It is, therefore, very much better to have a piston which is slightly leaky than one which is too tight. A strong spring and a short card will often do away with troubles in that direction.

A more serious source of inaccuracy which is likely to creep in when taking cards from high-speed engines is the stretch of the string and the effect of inertia upon it. If a constant tension could be kept upon the cord, the length of the string would not vary throughout the stroke but the effect of inertia upon the tension of the cord causes it to be of different lengths at the fast and slow portions of its motion, thus causing the cut-off and compression to be distorted. Experiments have been made which prove that in some cases this effect of inertia may become quite serious.

The stretch and sag of the string are often made as small as possible by replacing the greater portion of the length of the string by some positive piece of mechanism which will not stretch or vibrate, such as a steel rod or bar, which is guided or supported, so as to make a positive connection except for the few inches of string which are necessary at the end.

In a small engine any inaccuracy in the indicator diagram may not be of such importance as in a large one, since any inaccuracy of a card taken from a large engine is multiplied by a much larger engine constant than in a small engine, and as the size of the engines has increased enormously since the first indicator was used, the size of the indicator card with which the power is measured has remained the same or is even smaller than it was then, so that it is of great importance that a reliable and accurate diagram should be had.

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Some Uncertainties in Steam Engineering.

The owner of a steam plant is often at a loss to know just what is necessary in the equipment of his plant and for that reason he often consults his engineer or asks him to advise the kind of apparatus necessary for the most economical operation of his plant. It is a mighty peculiar proprietor who will not save himself some money in the operation of the plant and if he can be assured that the installation of a certain piece of apparatus or the adoption of some power plant necessity will save him money, he will usually have it installed.

The question which usually arises is: "Will the addition of a steam separator, or a feed water heater or some pipe covering better help the plant"? In answer to those questions there will undoubtedly be a decided "Yes" and for that reason few plants are now found which do not have these and many similar devices installed. There are many other questions, however, which cannot be answered by a "Yes" or "No," among which may be mentioned: "Is it economical or expedient to put in a superheater or economizer?" and since these are not yet established facts, only in a comparatively few plants are they to be found.

The above questions are merely representative of those which are continually being brought before the engineer and may be classed as the certainties and uncertainties of steam engineering and it is perhaps the latter which makes the study of engineering most interesting. To this list of uncertainties also belongs the question as to which is the best and most economical prime mover to be used; is it better to use a water-tube or fire-tube boiler; are alternating and direct currents the most economical for a certain plant; is it better to use 110 or 220 volt lamps, and so the questions which cannot be answered without investigation can be multiplied.

Each of the above uncertainties and, in fact, everything relating to engineering, has its advantages and disadvantages, and if the relative advantage of a certain piece of apparatus out-

weighs its relative disadvantages, then it would be advisable to select the one which had the greatest number of points in its favor, considering the particular plant in which it is to be used. Take, for instance, the economizer. After it has been definitely decided what amount of heat can be absorbed from the flue gases economically, it must be then determined what saving can be effected by such extraction of the heat.

It is here, as in the consideration of a number of other uncertainties, that the engineer must make calculations on a business basis. Against the saving of the heat must be entered the cost of the economizer and its erection, its deterioration, cost of mechanical draft apparatus and the automatic scraping device to keep the tubes clean, etc., and if the saving in heat more than balances the interest on the capital invested, then the use of the economizer could be recomemnded, and if not, then the plant could be run more economically without it.

This is merely given as an illustration to show how hard it is to answer some questions if all the attending circumstances are not given, and in the discussion of some problems it may be that both arguments are right and yet they both may be wrong, like the six blind men who were discussing the elephant; they each were right but they all were wrong.

Steam Pipe Systems. There has probably been no part of the power plant equipment which has caused the engineer more trouble and disappointment than the various steam pipe lines around the plant, especially if they have been poorly designed, and there are very few plants in which the engineer has not made some changes in the piping or he would like to do so if he were allowed the money or had the opportunity. This is perhaps more common in the plants erected some years ago than in those which have been recently erected, but even with all the care and attention to design which have been given to this subject, there are many steam pipe systems which are far from being satisfactory.

Formerly, before the use of high pressures and superheated steam, the steam piping was often the last thing thought of. The engines were carefully erected at one part of the building and the boilers at another and the pipe lines were run from one to the other with whatever lengths of pipes and fittings were available, but in the past few years there have been just as much forethought and careful consideration in the design and installation of the piping systems as is given to any portion of the plant. According to the old maxim that a chain is as strong as its weakest link, the power plant may be said to be as reliable as its weakest part and this part very often is the main steam pipe.

This may be due to several reasons: lack of care in design and lack of care in installation. Unlike the design of many parts of a steam engine or steam boiler, the piping is not a matter of calculation, but rather a matter of experience. Of course, it is necessary to know what the diameter of a pipe must be to efficiently perform a certain work but aside from this, the position of the valves, the allowance for expansion and the flexibility of the system are all matters in which experience has been the best teacher. It has also come to be realized that the running of steam pipes is an entirely different proposition from that of running the pipes for a low pressure heating system and consequently men are now employed who make a specialty of running high pressure steam lines, men who have been engineers and who realize exactly what a stripped thread or a sprung joint may mean.

As a result of this experience, steam lines are now being installed in which simplicity of arrangement is the most prominent feature. This is usually accomplished by running a large sized header between the engines and boilers and connecting them with as short and direct connections as possible. With a proper arrangement of stop valves, each boiler or engine may be operated independently, as desired, and with the use of long radius pipe for the connections between the boiler and header and engine and header, expansion can be easily provided for without any extra joints.

The object of this arrangement is to do away with as many joints as possible, for the more joints that are used, the more weak places there are which are likely to get out of order and cause trouble. The trouble in a pipe line usually is in proportion to the number of joints, and the fewer joints that are used to accomplish a certain purpose, the less will be the liability of a breakdown from that cause.

The ideal piping system would be one that has no joints but, since that is impossible for many reasons, the minimum number possible should be used. In some recent power plants the number of joints has been reduced to a minimum by using extra long lengths of pipes and so much has been thought of the reliability of the system that the duplicate system of piping has been discarded, in plants where these long lengths have been used.

The use of the receiver separator has done much toward increasing the reliability of steam lines by decreasing the vibrations due to sudden rushes of steam through them. They equalize the flow of steam through the pipes by storing up the steam, which comes from the boiler continuously and which is used by the engine only intermittently, and prevent any reciprocation of flow or wiredrawing the steam in the pipes.

To Our Contributors and Questioners.

Owing to the many communications which we have received, it has been impossible to publish all of them in each issue, so that we would therefore ask the indulgence of our contributors and those who ask questions, that, if they do not see their communications in print, or hear from us, to wait for a coming issue. It is our desire to give each contribution sent in our most careful consideration and if it has any important engineering value we will publish it as soon as space permits. The same is true of questions. If we only received 100 questions every month and it took only 30 minutes to answer each question, that would consume 3000 minutes or 5 working days of 10 hours each. There is nothing that we enjoy better than to answer questions but we must ask that you await your turn, and we will try to give you the best engineering answer that can be procured.

Indicator Spring.

In selecting an indicator spring for a given pressure, it is advisable not to use one that is too light. Two inches are sufficient for the height of a diagram and the indicator will be less liable to damage if the proper spring is used. The gauge pressure divided by 2 will give the scale of spring to give a diagram two inches high at that pressure.

OIL SEPARATION FROM EXHAUST STEAM

Some Different Methods of Draining the Oil from the Separator

When oil is fed into the cylinder of an engine, there is always an amount used in excess of that which is needed for proper lubrication, so that the exhaust steam carries with it an amount of greasy or oily matter. A good portion of the oil in the exhaust steam can be reclaimed, if treated properly, for use again, thus effecting an appreciable saving in the oil bill. Aside from this, there are a number of other cases where the removal of oil is necessary, as its presence is often detrimental to the subsequent use of the exhaust steam.

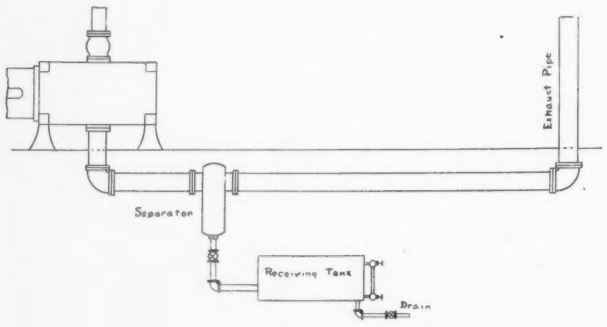

Fig. 1.

When exhaust steam is used for heating, if the oil is not removed from the steam it will coat the pipes and radiating surfaces with a film of oil, thus lowering their radiating efficiency. When used in open feed water heaters, it must be separated from the feed water so that no greasy matter is introduced into the boilers. When used in surface condensers or closed feed water heaters the grease should be extracted from the exhaust steam before it strikes the cool walls of the pipes or coils and when used with jet condensers, it should be either separated first or skimmed afterwards, or both, as the injection water and steam are mixed together and a part of the mixture is used for the feed water in the boilers.

While the separation of oil from exhaust steam follows the same laws as the separation of water from the steam, the former is vastly more difficult to perform efficiently, as the oil in the exhaust is commonly in such a form as to adhere to the surfaces of the separating device, clogging its passages and decreasing its efficiency of operation unless special precautions in the design or periodical cleaning are resorted to. In condensing practice, oil separation is rendered still more difficult by the high velocity of the exhaust into the condenser which makes it very difficult to successfully trap the small particles of oil suspended in it.

Oil separation resolves itself into two problems, according as the removal of the oil is to be effected before or after condensation of the steam. In the former case some sort of mechanical oil separator is used, while in the latter case, flotation or filtration or both are often resorted to with good success. When water of condensation which contains oil is allowed to stand or flow with a small velocity, the oil will rise to the top from whence it may be drawn off and allowed to pass through a filter for further use. The remaining water may then be passed through some form of filter for final clarification before it is used again. The practice of condensing the exhaust is used only in connection with jet condensers or open feed water heaters where the presence of oil is not objectionable.

Since the separation of oil from the steam is a very similar process to the separation of the water from the steam, there are many oil separators which are identical in design with those used for water separation; there are some which are modifications of the steam separators, while some manufacturers use entirely different designs for each class of service.

The particular difference between oil and steam separators is the fact that while a steam separator will work indefinitely without requiring attention, the oil separator will soon lose its separating efficiency if the surfaces are allowed to become coated with oil and therefore since it is particularly desirable that all the oil be removed from the steam, there should be some means of examining the baffle plates and cleaning them when necessary. The oil separator should always be placed between the engine and feed water heater or between the engine and condenser.

As oil separators are placed on exhaust pipes, they are not required to stand the high pressure that steam separators are required to endure and can be made lighter, but the other requirements are nearly the same, among which may be mentioned large volumes, so that the velocity of the steam is reduced through them; separation of the oil from the current of the steam; continuous method of draining the oil chamber; gauge glass for determining the interior height of the liquid; and a minimum liability to clog up with foreign matter.

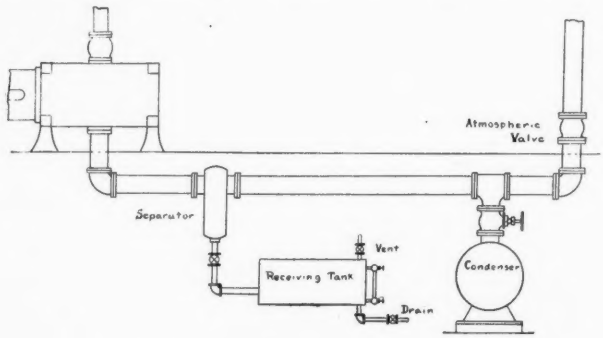

Fig. 2.

The method of draining the receiver space of an oil separator differs from the methods which are applicable to steam separators, since the interior of an oil separator is rarely under pressure. When an engine is run non-condensing, the separator may be connected up, as shown in Fig. 1, where the receiving tank is located below the separator. When desired, the valve under the separator may be opened and the head of oil causes it to flow into the tank below. The receiving tank is usually made of generous dimensions so that the contents can be drained off at intervals, when it is filtered and the oil reclaimed.

When separators are connected to exhaust lines which have a pressure below the atmosphere, a somewhat different method of connection must be adopted, as shown in Fig. 2. With this arrangement the receiving tank is placed below the receiver and when in operation the drain valve and vent valves are closed and the oil will flow down by gravity. When it becomes necessary to drain the receiving tank, the valve under the separator is closed and the vent and drain valves opened.

With either of these arrangements, it is advisable to connect an equalizing pipe from the top of the tank to the exhaust pipe so as to prevent any air pockets from forming in the tank. When used with the arrangement shown in Fig. 2, the equalizing pipe should have a valve on it which is manipulated in the same way as the separator valve, remaining open when the separator drainage is accumulating in the tank and closed while the tank is being emptied.

Sometimes a float is used within the tank which blows a whistle when the tank is nearly full and a connection is made with the live steam, which, when the proper valves are closed, forces the contents through the drain valve. A trap can be used in place of the tank so located that the drainage from the separator flows to it by gravity, but it must be of a design which allows the liquid to be transferred from a lower to a higher pressure by the action of the higher pressure.

When the separator on a vacuum line is at a sufficient elevation, about 45 feet above the receiving tank, its drain pipe can be carried downward and its end always kept below the level in tank which seals the end. So long as the seal is unbroken, the oil will drain off from the separator and the tank can be emptied whenever necessary by merely opening the drain valve. To insure the requirement that the end of the pipe leading to the separator should always be below the level of the oil in the tank, the outlet of the drain pipe should be well above the end of the pipe leading down from the receiver chamber of the separator.

The Value of Technical Training in Steam Engineering.

By T. H. Reardon.

In all the lines of industrial enterprise in our age of progress and keen competition, there is one thing that stands out in bold relief—in sharp but agreeable contrast to the old time methods of forty years ago. This is, in brief, the desire to know in detail what the cost of production is. It matters not whether the production be horse power hours, kilowatt hours or units of any other kind representing various quantities of a particular product with its corresponding market value.

The successful business man, the man that is alive to his own interests, must know not only the actual cost of the finished product, but he must know the cost incident to each step in the production of the particular commodity which it is his aim to furnish, and which, after its conversion into dollars and cents, determines either his success or his failure.

The desire for small outlay and large returns is widespread and the methods employed to reach this goal by men that have more capital than technical knowledge—while amusing even to "common-sense" people, induces conditions that are very distressing to the thoroughly competent man that is expected to reach the mark, even though it involves impossibility.

But to return to our subject. The engineer that is to be master of his business must be able to start with his fuel at the furnace doors, and he must account for it both in quantity and quality, tracing its compounds to the point at which they leave the stack and not overlooking the residue that goes through the grates into the ashpits.

It is not expected that the engineer is to be a chemist and determine the chemical composition of his coal—that would be asking too much—but the steam plant owner should insist on knowing the number of heat units per pound in the coal that he pays for, and when the engineer is supplied with this data, he should be expected to account for the heat units, and state in detail what disposition has been made of them.

If 75 per cent. of the heat units in the coal enter the water in the boiler it will be a very respectable showing indeed. Of course, a whole lot will depend on the attending conditions; if natural draft is used, the stack temperature will have to be high enough to make the fires burn properly even though it involves the use of an excess of air.

There seems to be no good reason why boilers should not be bricked in almost completely, or at all events, covered to prevent the radiation of heat. Stationary engineers would undoubtedly learn much to their advantage by noting the severe conditions under which locomotive boilers are operated, as regards loss of heat by radiation, especially in winter time, and how efficiently they are protected even under extreme conditions.

After doing all possible to prevent radiation, the engineer's next effort should be directed to the matter of obtaining a low up-take temperature; heat going anywhere except into the water in the boiler is in reality thrown away at the start.

The up-take temperature may be ascertained most conveniently by means of a suitable thermometer which can be obtained at a very moderate cost, the velocity of the chimney gases can be deduced by ascertaining the draft by means of a U water tube, and knowing the area of the stack, the volume of the gases can easily be ascertained. The volume of gases discharge in an hour can be calculated, the volume converted into its corresponding weight, and by taking the specific heat of the flue gases, which will usually be about .24, the number of heat units escaping from the stack can be easily calculated. An analysis of the flue gases is important, as this throws light on several important matters, among which are the following: proportion of carbon completely burned, present as carbon dioxide; carbon incompletely burned, present as carbon monoxide; sulphur if it occurs in the fuel will be found as sulphur dioxide. The remainder will be air and free nitrogen.

Having considered the quantity of heat evolved by the combustion of the fuel, assuming that combustion is perfect and that a pound of coal will evolve 14,500 heat units, 75 per cent. of this may be expected to enter the water in the boiler, and to cover sources of loss due to radiation from steam pipe, engine, etc. We will suppose a total loss of 35 per cent. of our heat units before the steam enters the engine cylinder, which it does at an initial pressure of 200 pounds per square inch absolute pressure, and that our terminal or release pressure is 1 pound per square inch absolute. Steam of the above initial pressure contains 1198.4 heat units per pound measured from water at 32° F., and has a temperature of 381.73° F. Steam at the temperature of the release above equals 101.99° F., and carries with it to the condenser 1113.1 heat units per pound. The difference in a pound of steam between its entering the cylinder and its escape from the cylinder expressed in heat units equals 85.3.

As we have assumed a relatively low temperature for our steam as it goes to the condenser and further for the sake of simplicity, we will leave out of account the matter of recovering any heat from the exhaust steam, which, as stated above, carries 1113.1 heat units to the condenser per pound of steam exhausted. Although our pound of steam at admission contains 1198.4 heat units, that number of heat units cannot be charged up as being derived from the energy in the coal, for we do not start with water at as low a temperature as 32° F. We can safely assume that the temperature of the feed water will be about 60° F. without making use of a heater, so the number of heat units communicated to a pound of steam will be 1170.4 and the number of heat units converted into mechanical work in the cylinder is 85.3, as given above.

Now adopting the most rational expression for efficiency, we will divide the mechanical work done by a pound of steam in the cylinder expressed in terms of heat units; that is, dividing 85.3 by the number of heat units which we have actually put in each pound of steam, starting with water at a temperature of 60° F., or 1170.4, this will give $\frac{85.3}{1170.4} = 7.288$ per cent. for the efficiency in the cylinder. Now, as regards the combined efficiency. We assumed at the start that 35 per cent. of our energy was lost both in the up-take and through radiation in its several forms, so we had only 65 per cent. of the energy in the fuel really entering the cylinder, which will make an all round efficiency of $7.288 \times .65 = 4.747$ per cent. of the energy in the fuel appearing as mechanical energy in the engine and this will be still further reduced by back pressure and friction in the engine. It will be seen from this that the thermo-dynamic efficiency of the steam engine is extremely low and even with the conditions taken in this article the mechanical energy obtainable from a pound of coal is surprisingly small.

There is another expression for the thermo-dynamic efficiency of the steam engine represented by the formula $E = \frac{T - t}{T}$, in which T represents the absolute temperature of the steam at admission and t represents the absolute temperature at exhaust, the efficiency being denoted by E. Absolute temperature being the common temperature in Fahrenheit plus 460. This particular expression while largely used in the theoretical discussion of the steam engine is not regarded with favor by the writer.

Its application may be illustrated by considering the analogy in case of the water wheel. Let H equal the level of water in dam above the tail race and let h equal the level of water in dam above sea level, then $\frac{H}{h}$ equals the efficiency, a rather queer expression as we are not largely concerned with either the tail race water nor the exhaust steam when we are unable to follow efficiency any farther.

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The leakage of steam in the cylinder of an engine usually has so little effect on the lines of the indicator diagram that it can scarcely be detected.

LETTERS FROM ENGINEERS

IN ORDER to make this department of THE PRACTICAL ENGINEER as interesting as possible, a moderate rate will be paid by us for all contributions published under this heading. However, we do not assume responsibility for the ideas or opinions expressed. None need hesitate to contribute because of inability to draw or write well. We will redraw or revise whenever necessary—it is the idea we want. New ways of doing old things, criticisms of accepted theories, and general engine-room experiences are especially solicited.

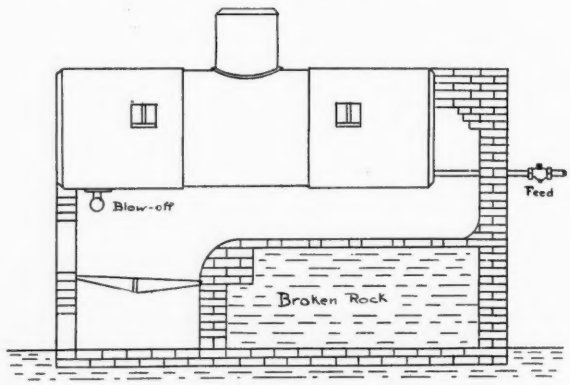
About Boilers.

EDITOR THE PRACTICAL ENGINEER:

What I shall have to say about boilers will not be a criticism on what someone else has written, neither will it be the exploiting of theories, either scientific or the result of ignorance, but will be the conclusions deducted from actual experience as a machinist and engineer, and as much technical knowledge as I have been able to gain while engaged in those occupations.

For the majority of places where boilers are used to furnish steam for stationary engines, after taking into consideration good steaming qualities when properly set, small cost of maintenance, in the line of repairs, ease of cleaning and safety when the workmanship and materials are good, I would recommend the return tubular (fire-tube) boiler.

Have a dome on your boiler. The only argument I have ever seen advanced against a dome that looked at all reasonable, was that it weakened the shell of the boiler, and made it more liable to explosion. In answer I would say: "Did you ever see a locomotive boiler without a dome?" "Did you ever see any class of boiler that did its work under such unfavorable conditions, and do it so successfully?" With a dome you get drier steam, and there is far less danger from water getting over into the engine and causing more damage in a few minutes than the difference between the price of a dome and a domeless boiler multiplied a number of times, would amount to.



Boiler Setting

In my judgment, it is more satisfactory to use a dome than to draw the supply from so near the water line, and then use a separator to extract the moisture out of the steam, admitting, of course, that in very long lines of pipe the separator with its adjunct steam trap, etc., is a necessity in any case.

The dome and, in fact, the whole top of the boiler should be covered with from one and one-half to two inches of one of the several makes of plaster covering, composed of magnesia and asbestos, which are to-day standard articles which no owner of a steam plant can afford to do without. Bricks and mortar should touch the boiler as little as possible; in fact, only fire brick and clay should come into contact with the metal.

Instead of the large open space behind the bridge wall, build the bridge wall about one-half the standard height, fill in the space between it and the rear wall with broken stone, then build a smooth surface of bricks from the top of the bridge wall on a rising incline to the rear arch wall, passing under the end of the boiler about the usual distance that the bridge wall is from the boiler. Have a small door with fire brick lining in the rear wall, so that if any ashes accumulate they can be shoved with a rake to the grates and thence to the ash pit.

A 100 horse power boiler which I set in this way, about six years ago in an electric station where there are two other boilers in use, is admitted by the owners and all who have had it in charge, to be an unusually good steamer. But to me the ideal way would be to have the wall slope gradually from the grates to the rear wall. That is, the bridge wall present a convex surface, and the rear end a concave surface to the fire.

A full arch front looks best and is more convenient to fire, but the front arch is constantly needing repairs; the half-arch front needs very little repairs, but be sure to support either by side brackets, making provision for expansion. Have separate connection or outlet for your safety valve, so that a stop valve may be put in the main line as close to the boiler as possible.

Feed the water supply into the back and just below the bottom row of tubes, and pipe it in such a way that it will be as well protected from the direct action of the flames as possible, and further protect it by winding with asbestos rope. Blow off at the front end from the bottom of the shell as close to the front head as possible, reinforcing the head at the point where the shell is tapped, protecting the pipe the same as the feed pipe.

A hand hole in the front head is a necessity, but a hand hole in the rear head is a debatable point. Tap the boiler for bottom of water column at largest diameter, and for top of column at the top of shell. A reason can be given for all of the above assertions.

Bangor, Maine. H. H. Woodworth.

Hot Bearings and their Treatment.

Editor The Practical Engineer:

The article by J. E. Noble in the February issue of "The Practical Engineer" about hot bearings would have been very much better if he would have answered the question: "What is the cause of the bearing on the connecting shaft of an engine getting hot on the crank end?" in the following manner:

Get a gallon of kerosense oil and have it ready; also a quart of new engine oil. About five minutes before shutting down, pour the kerosene in the crank end bearing; this will wash out the bearing and oil ways; then before stopping the engine pour in the quart of new engine oil. After this examine the bearing to see if the quarter-boxes are not worn so that they will leave too much play in the bearing, which would allow the bottom shell to ride back and forth in the pillow-block, causing the shell to heat up. If this is the case, set the quarter-box up to the shaft, leaving a space between the shaft and quarter-box of say .014 of an inch, which is the thickness of ordinary tin, and which may be used as a gauge to go by. For the clearance under the top shell get some No. 19 lead wire, lay two pieces across the shaft.

Having done this, lower the cap down and screw hard upon it, then lift up the cap and shell and with a micrometer see how much the lead wire has flattened. This should measure .015 of an inch; if it does not, take out the liners and repeat the screwing down until the desired thickness of lead is reached, but in the first place after the cap was screwed down, take a scriber and mark the bolt head and cap; so that if the first lead you take is right, when the cap is replaced the bolts may be screwed down until these marks come together again. At the same time remember that the shell must bear on the liners placed between the top shell and the quarter-box.

If the shaft is level and in line with the cylinder and the oil way clear, this will give a cool and smooth running bearing. If this does not remedy the trouble, then I would advise taking out the bottom shell and recut the oil ways.

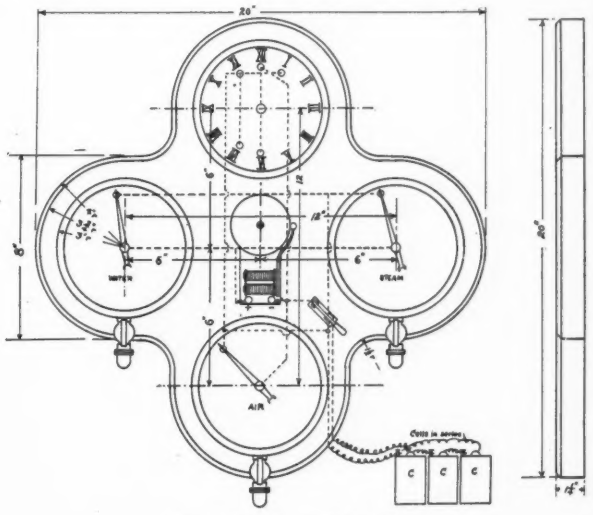
Brooklyn, N. Y. Maurice W. Campbell.

Electrical Connections for Gauge Board.

Editor The Practical Engineer:

I enclose herewith a sketch showing the way gauges in our engine room are arranged, which will probably be of interest to a great many engineers. This method enables us to keep tab on the pressure of our steam, air and water supply, the clock being also connected up so that the alarm will sound when it is time to blow the whistle.

The electric wires are so arranged that the bell rings when the clock is at 7 A. M., our starting time, at 11.55 A. M. and 1 P. M., our noon hour, and also at 5.55 P. M., our quitting



Gauge Board for Engine Room

time. This system enables the engineer to blow the whistle on time, as he can hear the bell in any part of the engine-room and it saves a great deal of his time watching the clock. The steam gauge is so connected that at the blowing-off pressure the pointer on the gauge makes a contact with the button inserted in the dial and connected with a wire under the dial.

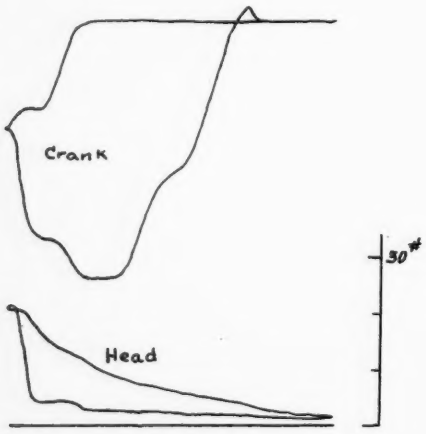
The air gauge shows the pressure of compressed air carried in our receiver, and at its blowing-off pressure the pointer on the dial forms a contact with the button in the dial and rings the bell, which can be heard all over the engine-room. The water gauge shows the amount of water in our supply tank, and in order to avoid having the tank run over, the wires have been so arranged that the bell rings at the pressure produced by the required height of water in the tank. It can be readily seen what a great convenience this arrangement is to an engineer.

Trenton, N. J. G. C. C.

Brains and the Indicator Fixed this Engine.

EDITOR THE PRACTICAL ENGINEER:

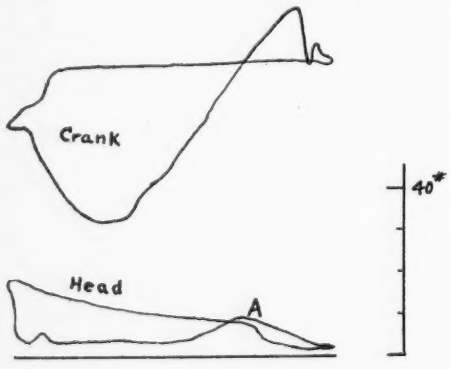
Enclosed find three cards taken from an 8 x 10 automatic engine, which may perhaps interest your readers as showing what an inexperienced person can do to an engine in attempting to "fix" it.



Card No. 1.

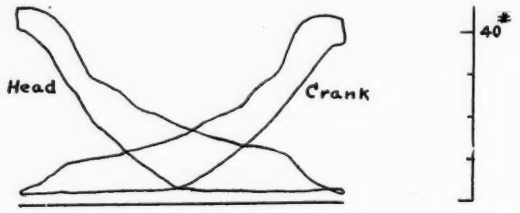
One morning recently, a laundry in our town telephoned to come up as quickly as possible and see what was the matter with their engine. "We can't keep the crank pin brasses from heating and have to get out the wash." As this is one of the many jobs that falls to my lot, I was sent up with the indicator to locate the trouble.

It did not take me long to find out that the superintendent, in attempting to take out the knock the previous day, had



Card No. 2.

moved the valve rod with the results as shown on Card No. 1. "But it stopped the knock all right," were his concluding words when telling me what he had done. Card No. 2 was taken when the valve had been moved slightly in the direction it had to go. I cannot account for the rise in the exhaust line at "A." Perhaps some of your readers can throw some light on the cause of this. Card No. 3 was taken after resetting the valves. No further trouble was experienced with the brasses heating, but before leaving I convinced them that what they wanted



Card No. 3.

was new brasses and repairs to a leaky valve.

I think Card No. 1 is about as peculiar a card as I have ever taken and I run across some funny ones.

Clearfield, Pa. W. A. S.

As Things Are Often Done.

EDITOR THE PRACTICAL ENGINEER:

I had business one day to transact with the foreman of a wood-working factory and upon entering, found everything idle and the men standing about waiting for power. Upon inquiring for the foreman I was told he was in the engine room. As I passed through the fire room I met the engineer. "Hello, Ike! what is the trouble?" "I don't just know; the old engine has a bad pound in her and I do not feel like running it in that condition." "Who is doing all the hammering?" I inquired. "Oh, George and one of his men are trying to fix it; if he keeps on I guess he will finish it at the rate he is going." I went to the engine room door to have a look. Well, there was George standing on a box with a 20-pound sledge such as I have seen in quarries for sledging out Belgium or paving blocks, driving down the key on the crank pin. "Well, George, do you think it will run smooth after you get it down?" "I guess it had ought to."

Some writers say that they never slack a key back after driving or slack the screw when pulling up or screwing down on the wedge. I thought it would be policy to advise George to slack up in this case if he was not looking for further trouble. I inquired if they were sure that was where the trouble was and they said they knew their business about as well as some men with an M.E. following their name, so I took the hint and moved on. The fly-wheel had worked loose and slipped ½-inch sideways on the shaft, and caused the pounding. The engineer was bothered so much with this foreman that when anything did happen he let him bang away all he wanted to.

About a year after this, the engineer resigned and the one who took his place one morning sent a man over to my plant, asking me to come and see if I could help him as he was having trouble. I inquired what the trouble was when I got in his place, as the engine was standing. He said he could not hold steam 15 minutes at a time. "Well, start it up; let's see how it acts." It was soon found out that the head end dash pot would not seat and, in fact, did not move, and being wide open, allowed the engine to blow through. "Give me a monkey-wrench; I will fix it; or, turn that bolt out yourself." This fellow had a ¾-inch bolt screwed in the dash pot so it could

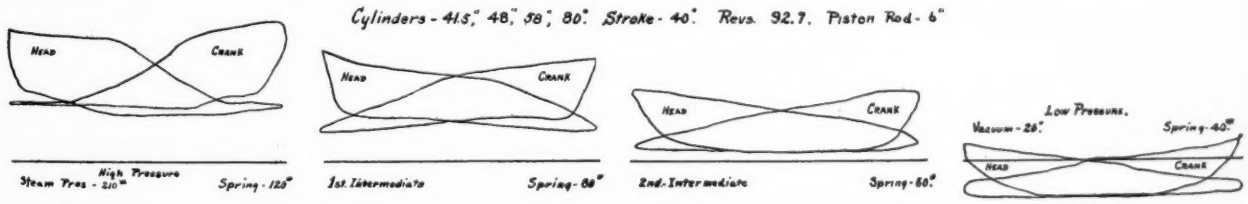
not get down after it was once up. This fellow was always monkeying with the engine and was one of those fellows who never knew when to let well enough alone. He was always in trouble and never knew how to get out of it.

No. Abington, Mass. A. T.

Quadruple Expansion Engine Cards.

EDITOR THE PRACTICAL ENGINEER:

Enclosed you will find one set of cards taken from the engine of one of the largest steamships afloat, the engine being of the quadruple expansion condensing type. The cards were taken after the engine had been running for 48 days without a stop. As I know some of your readers have never seen a set of such cards, I think they might prove interesting. The diameters of the cylinders are 41.5, 48, 58 and 80 inches, stroke 40 inches, diameter of piston rod 6 inches, revolutions per minute 92.7, steam pressure 210 pounds per square inch, and vacuum 26 inches.



Quadruple Expansion Engine Cards.

San Francisco, Cal. C. L.

Tandem Compound Engine Troubles. Get the Right Kind of Packing for the Right Place.

EDITOR THE PRACTICAL ENGINEER:

In the plant where I am employed as engineer, there was installed a 10" x 19" x 14" Ball and Wood tandem compound engine rated at 150 horse power at 120 pounds boiler pressure. From the very time steam was admitted to its cylinders, there was a heavy pounding at the back of the high-pressure cylinder, which would come and go and sometimes remain for hours and which could be heard a distance of a block very easily.

About one year after the above engine was installed, another engineer and myself hired out to the above electric plant. The company was on the verge of buying a new engine upon recommendations of former engineers who had been called in to remedy the trouble. They said this compound engine was no good.

We put our heads together, and with coats off, took observations for a week, in the meantime inspecting the interior of the engine and making sure that valve rods and piston rods were of the proper length and other points relative to such troubles, all of which we found satisfactory.

Then we commenced experimenting with the distribution of the steam in the low-pressure cylinder by adjusting the valve, but this did not help in the least. We also made some changes in the steam line by changing the position of the separator and found that the pounding was not quite so frequent or loud as before. Encouraged by these efforts, we kept on slowly and steadily.

The next move was for the store room to inspect the packing, which was handled at that time in large quantities. This packing was made by one of the best known firms but upon examination we found that it was only intended for a working pressure of 80 pounds, while we were carrying 120 pounds. We immediately wired for the same make of packing to be used on high pressures at 120 pounds. We repacked the high-pressure rod with our new packing and from that day to this, a period of over a year, we have failed to have or even hear the slightest pound and we have as quiet a running engine as there is in the State of Colorado.

The theory of the trouble was simply that the packing which was formerly used did not have the strength to withstand the vibrations of the piston rod caused by a little water coming in with the steam; also, the high-pressure piston, having only one packing gland behind the low-pressure cylinder, was simply slamming itself against the cylinder walls, thereby producing the heavy pounding.

This pounding seemed to occur on the back end of the high-pressure cylinder when the engine was on the inward dead centre. Had this engine had an external piston rod, or tail rod, and packing gland on the high-pressure cylinder, this trouble would not have happened, but the high-pressure packing solved the mystery.

We use a jet condenser with this engine and obtain constantly 20 inches vacuum, which is good for an elevation of 7500 feet above sea level. Water at this level boils at 200 degrees Fahrenheit.

In my ten years' experience of engine running in electric plants, this is one of the most curious and most troublesome but easiest remedied troubles I was ever up against or ever heard of.

Alamosa, Col. E. J. A.

Rodney's Troubles.
Or Do We Need a License Law in Michigan?

(Eighteenth Letter.)

I haint got mutch to do tu day, mistur editur, so i thot i wud rite u a fu lines to let u no that i am stil in the biznus az u no it iz verry slak with me at this time ov the yeer. let me se, the last job i dun wuz up at lige whippuls. i ground sum fodder and sawed up sum 4 fut wud fur him. henry iz alwaze luking up sumthing to ketch me with and onli fur mi writen to u to git ure noiledge on these kwestions ide be berried in a snobank. henry got to tokken about a vackum the uther day, and he says a vackum is a space what haint got enny thing in it. iz an empty corn crib a vackum mistur editur? if it iz how could it be uzed with a steem injine? i think sum body iz trien to maik a fule of henry fur i kind ov think that this hear vackum is sumthing that belongs to the perpetshual moshen masheen, sumthing that never run nor never wil.

i got up to the power hous a fu days ago and while i waz tokken to 1 ov the firesman, the cheef kame in to the fireroom with annuther man. thay were bizzy tokken about 1 ov the field

magnets bein burnt out and how mutch trubble thay had fixen it, thay must ov had a lot of trubble fixin enny thing out in the fields this wether, fur thare iz 25 inches of sno on the level enny whare in munrow kounty now. it shos u mr editur that i haint the onli 1 that haz trubble with injines and bilers. henry waz reeding to me frum ure buk about a thrasher injine and biler blowen up and at the end ov the peace it sed, thare waz no apparent kaws fur the exploshun. ile bet a peck of chesnuts against a sent that sumbuddy tide a roap or a wire onto that safety valv leever and that waz what maid it blow up. please find out if ime rite and let me no in ure next lettur.

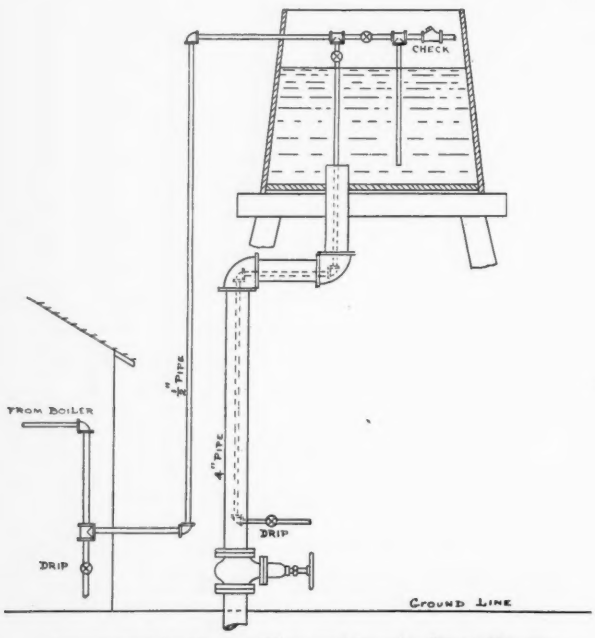
ures trooly rodney gumkirk
orkners korners
munrow kounty
mishegan

How the Water Hammer was Stopped.

EDITOR THE PRACTICAL ENGINEER:

In your April, 1904, issue, you answered my question as to the cause of the water hammer in a pipe leading to an elevated tank and according to your suggestion, I got up the following arrangement, which works all right:

I ran a ½-inch steam pipe outside of the 4-inch pipe up to the tank, connecting it to the ½-inch pipe which runs down



Arrangement for Heating Water and Stopping Water Hammer

inside the 4-inch pipe. The ½-inch pipe through the 4-inch pipe was allowed to remain as it was, a valve being placed on the part that extended beyond it, so that it could be used as a drip. The ½-inch pipe leading into the water and to the check valve was connected as shown.

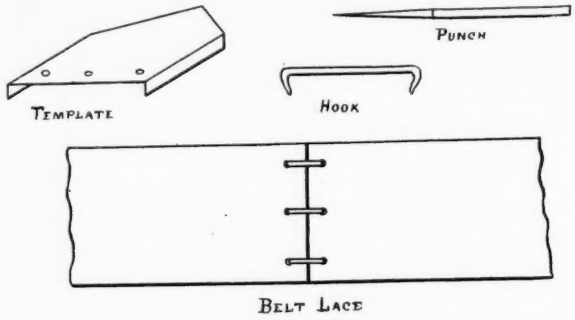
Steam is now turned on below full and the small valves are throttled so that just enough steam goes through to heat the water in the tank and in the 4-inch pipe. It works all right and there is no water hammer.

Danbury, Conn. J. M.

Canvas Belt Joints.

EDITOR THE PRACTICAL ENGINEER:

I am employed in a hat factory and I would like to give you some of my experience with belting. We have been using rubber belts in the sizing room, which is a wet, steamy place. The rubber would come off the belts and get into the hats,



Canvas Belt Joint

making them unfit for use. I replaced the rubber belts with canvas belts, which work very well in steamy places.

The accompanying illustration shows the manner in which I mend these belts. I use a tin template with holes the right distance from the sides and ends. I place it on the end of the belt, square it off, mark the holes and then punch them with a long taper pointed pin. I don't use a regular belt punch as it cuts away the belt, weakening it and the hook will pull out. I use the Jones hook which makes a good and quick point. I keep templates of this kind for different size belts, the wider ones having more holes. I also use them on leather belts but in this case I use a regular belt punch.

Danbury, Conn. J. M.

Formula for Black Varnish Wanted.

EDITOR THE PRACTICAL ENGINEER:

I would be obliged to any reader of "The Practical Engineer" if he would let me know, through its columns, of a formula for making black varnish for arc lamp casings. I already have two formulas for such varnish but it gives a dull finish while I want a glossy finish.

Nazareth, Pa. J. A. J.

Compressor Valve Blew Out.

A compressor valve recently blew out in the shop of the American Steel Foundries, located at Chester, Pa., badly injuring five men. The accident occurred a few minutes before 7 o'clock in the morning when the employees at the shop were just about to go to work. They were standing around the time clock when without the slightest warning there was a deafening explosion and the place was filled with the dust from the moulding room floor and pieces of the scattered machinery. The shock of the sudden release of air was so great that a portion of the roof of the shop was blown away and every man within a distance of 50 feet of the compressor was blown over like a ten-pin. As there were a large number of employees in the shop at the time, the fact that there were no fatalities was surprising.

QUESTIONS and ANSWERS

THE editor will be glad to receive from the readers of THE PRACTICAL ENGINEER, such questions relating to engineering subjects, as may, from time to time, occur to them. All questions and answers should be addressed to the editor and accompanied by the name and address of the writer, which will not be published, however, unless especially desired. It is the intention that questions shall be answered by the readers, and even though the editor may, from time to time, publish answers and questions, he especially desires the readers in such cases to contribute any further information, in connection with the points raised, that they may consider of interest. All questions and answers received by the editor will be published, as far as practicable, but he reserves the right of editing or rejecting any communication.

Temperature of Steam and Water Mixtures. Pressure and Work Problems. Area of Safety Valves.

EDITOR THE PRACTICAL ENGINEER:

Will you kindly answer the following questions:

(1). If 16.7 pounds of steam at 90 pounds gauge pressure are mixed with 263 pounds of water at 73 degrees Fahr., what will be the final temperature of the mixture?

(2). How many pounds of steam at 90 pounds absolute must be mixed with 260 pounds of water at 60 degrees Fahr. in order that the temperature may be 93 degrees Fahr.?

(3). An engine using a jet condenser develops 90 indicated horse power and uses 28 pounds of steam per horse power per hour. The terminal pressure in the cylinder is 3 pounds absolute and the temperature of the mingled steam and water is 125 degrees Fahr. What is the quantity of cooling water required, if the temperature of the cooling water is 60 degrees Fahr.?

(4). In the top of a closed vessel is inserted an upright tube ½-inch inside diameter, 60 feet long. The vessel is 4 eet high. If both pipe and vessel are filled with water, what is the pressure per square inch on the top of the vessel and what is the pressure per square inch on the bottom?

(5). A grade is 1½ miles long and rises 600 feet to the mile. How much work is performed in pulling a load of 10,000 pounds up the grade, friction being neglected? What horse power will be required, if the work is performed in 7 minutes?

(6). Will you please define the term toggle joint as applied in mechanics?

(7). What is the diameter of a safety valve for a 60 horse power boiler, the steam pressure being 90 pounds per square inch?

Portland, Oregon. A. E. W.

(1). 141 degrees.

(2). 7.6 pounds.

(3). 40,010 pounds per hour.

(4). 26.04 pounds per square inch at the top and 27.77 pounds per square inch at the bottom.

(5). 9,000,000 foot pounds. 38.9 horse power required.

(6). A toggle joint is an elbow or knee joint consisting of two links or bars so connected that they may be brought into line. When force is applied to bring them into this position, they can be made to produce great endwise pressure.

(7). A Philadelphia ordinance gives the following rules for finding the area of safety valves:

Every boiler when fired separately, and every set or series of boilers when placed over one fire, shall have attached thereto, without the interposition of any other valve, two or more safety valves, the aggregate area of which shall have such relations to the grate area and the pressure within the boiler as is expressed in the following:

Least aggregate area of safety valve (being the least sectional area for the discharge of the steam) to be placed upon all stationary boilers with natural or chimney draft:

Area of combined safety valves =

$$\frac{22.5 \text{ grate surface in sq. ft.}}{\text{Gauge Press. in lbs. per sq. in.} + 8.62}$$

The U. S. Supervision Inspectors of steam vessels give the following:

Lever safety valves to be attached to marine boilers shall have an area not less than 1 square inch to 2 square feet of grate surface and the seats of all such safety valves shall have an angle of inclination of 45 degrees to the centre line of their axis. Spring loaded safety valves shall be required to have an area of not less than 1 square inch to 3 square feet of grate surface of the boiler.

The Canadian Steamboat Act provides that the area of the safety valve must be equal to one-half square inch for every square foot of grate surface in the boiler.—[Ed.]

Setting Corliss Engine Valves.

EDITOR THE PRACTICAL ENGINEER:

I wish you would give me an explanation of how to set Corliss valves with two eccentrics.

Collinsville, Ind. W. C.

When a Corliss valve has two eccentrics, the setting of the valves is in reality an easier problem than when the engine is equipped with only one, because when setting the steam valves the eccentric can be moved regardless of the exhaust valves and when setting the exhaust valves the other eccentric can be turned independently. The work of centralizing the positions of the various parts, equalizing the movements and setting and adjusting the gear is practically the same as with the single eccentric engine.

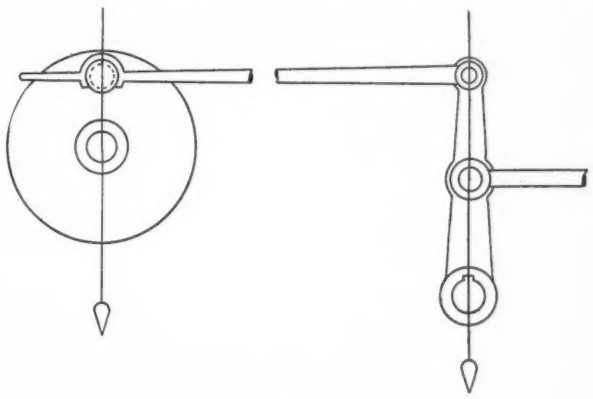


Fig. 1.

The first thing to do is to centralize the various parts and equalize their movements. Place the wrist-plate and rocker arm, as shown in Fig. 1, and with a straight-edge and scriber, mark the position of the wrist-plate, as at *a* and *b*, Fig. 2.

Turn the eccentric on the shaft to the dead centre and make a mark *c* to correspond to line *a* on the wrist-plate. Turn the eccentric to the other centre and in the same manner mark *d*. Then the mark *b* should be equally distant from *d* on one side as it is from *c* on the other. If the mark *d* is nearer *b* than the mark *c*, then the eccentric rod must be lengthened or so adjusted that mark *b* will be exactly between *c* and *d*, which proves that the eccentric rod is the proper length. When *d* and *c* are found to be correct, they should be made permanent marks.

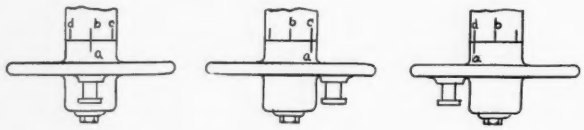


Fig. 2.

The lap of the steam valves should next be utilized. Remove the valve chest covers so that the ends of the valves will be in plain sight, as shown in Fig. 3. Three marks are usually visible which have been placed there by the engine builders, as *m*, *o* and *r*. The mark *m* represents the working edge of the valve, *o* the edge of the steam port, and the distance between marks *o* and *r* represents the amount the valve should lap over the edge of the port when the wrist-plate is plumb, the hooks engaging both catch blocks. Now raise the governor and insert the safety-stop and after setting the wrist-plate plumb by means of marks *a* and *b* and being sure the hooks have raised the crank-arms on the stems, the lines *m* and *r* should be exactly in line with each other. If the valves have not the proper lap, the radial rods connected to the wrist-plate should be so adjusted until *m* and *r* do coincide.

The wrist-plate should now be turned so that the lines *a* and *c* on the hub, as shown in Fig. 2, coincide. Then adjust the length of the dashpot-rod until the clearance spaces *s* and *t*, shown in Fig. 4, are obtained. Then turn the wrist-plate to the opposite extreme position so that *a* and *d* coincide. Adjust the dash-pot at that end of the cylinder so that the proper clearance at *s* and *t* is obtained. Now, hook the reach-rod on the wrist-plate and turn the eccentrics to one of the extreme positions so that the lines on the wrist-plate hub nearly coincide.

The valve now being open, the length of the governor rod should be adjusted so that the inner member of the hook just engages the projection on the knock-off cam. Move the wrist-plate by turning the eccentric until the lines on the hub coincide. The valve which has been raised should now be released and the dash-pot plunger properly seated.

The governor rod should be so adjusted that the steam-valve will be released by the time the wrist-plate reaches the extreme position in order to insure the valve being closed when the latest point of cut-off is reached, which point corresponds to the extreme position of the wrist-plate and eccentric with the governor in its lowest position; that is, when the collar or sleeve is resting on the safety stop. The governor rod on the opposite end should be similarly adjusted.

When adjusting the lap of the steam valves on double-eccentric engines, the valves have no lap as they do on single eccentric engines and it is therefore important to see that the valve arms are released from the hooks by the time the eccentric and wrist-plate reach the extreme positions, otherwise when the wrist-plate reaches its central position both ports will be open at the same time which condition will result in live steam flowing directly into the exhaust pipe, causing a considerable waste of steam.

When setting the eccentric, it is first necessary to observe the style of wrist-plate operating the steam valves. If the wrist-plate is of the style having nearly vertical radial rods, it will be seen that when the eccentric moves away from the cylinder, the hook corresponding to the head-end valve will be moving in the opposite direction to that required to open the valve; consequently the eccentric in this case must be moved around in the opposite direction to that in which the valve is to turn, when giving the valve lead. When the wrist-plate is similar to those employed on single-eccentric engines, the eccentric is turned in the same direction that the crank is turned.

To set the eccentric, place the full side of the eccentric on the dead centre nearest the cylinder, if the head-end valve is to be set first, and drop the reach rod on the stud in the wrist-plate. Turn the eccentric around on the shaft usually in the direction in which the engine is to run, and until the valve at the head-end of the cylinder has opened the port to the amount of lead, which will be indicated by the position of the lines *m* and *o* in Fig. 3. Tighten the set screws on the eccentric and have the crank turned to the opposite dead centre and examine the lead on the other steam valve. If it is not the same, adjust the wrist-plate connection being sure that there still remains the proper clearance space *s* and *t* in Fig. 4.

Before setting the exhaust valves, the amount of compression should be known, which can best be found by trial. When the piston is within about two or two and one-half inches of the end of the stroke, it is a good place to have the exhaust valves closed. To do this, turn the engine until it is about the required distance from the end of the stroke and turn the exhaust eccentric so that the mark on the valve will indicate that the port is just closed. When the engine is the required distance from the other centre, the other exhaust valve should be set in the same manner.

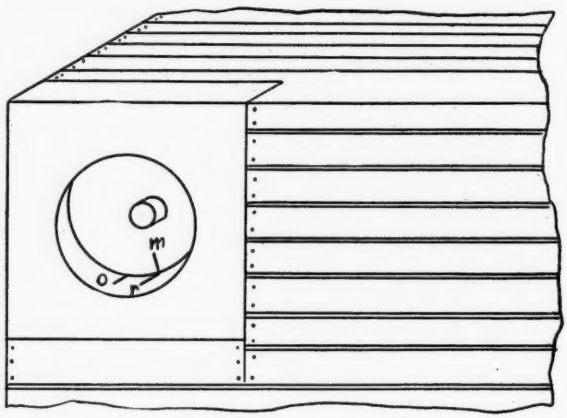


Fig. 3.

The governor must then be adjusted to give an equal cut-off on each end of the cylinder. As all Corliss engine governors are equipped with some form of stop device which cuts steam off the cylinder, and as this stop determines the lowest position of the governor at which the valves should hook on, it should be kept in place while the adjustments are being made.

Then unhook the reach-rod from the wrist-plate, and by means of the starting bar move the wrist-plate over until the lines *a* and *c* in Fig. 2 are nearly opposite each other. The head-end valve should now have opened the port to nearly the limit, which may be ascertained by the marks on the valve. Adjust the governor-rod so that the projection on the disc operated by the governor will come into contact with the inner member

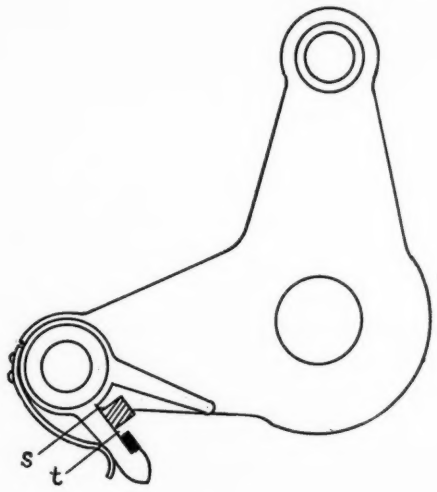


Fig. 4.

of the hook and so that the valve will be tripped or released when the marks *a* and *c* are exactly in line. As all governors do not move an equal amount to produce a given change in the point of cut-off, it is better to hook the reach-rod on the wrist-plate and have the engine turned in the direction it is to run, until the head-end valve is released, than to adjust the cut-off with the use of the starting bar. Measure the distance the piston has moved in the forward stroke when the steam valve closes and lay off the same distance from the crank end on the crosshead guide. Turn the crank in the same direction until the crosshead nearly reaches the mark on the guide and unhook the reach-rod and turn the wrist-plate around until the marks *a* and *d* are nearly opposite each other. Adjust the length of the rod from the governor until the projection of the disc operated by the governor comes into contact with the inner member of the hook, so that the valve will be released when the crosshead reaches the mark on the crosshead guide referred to, and the marks *a* and *d* are exactly in line. Both valves will then cut-off at the same point in the forward and return strokes.

Many engineers prefer to adjust the cut-off at about the average point when running under load, in which case the governor must be raised until the cut-off occurs at this point. If a more accurate adjustment is required, the use of the indicator will indicate more exactly how the cut-off should be adjusted.

The valve-chest covers can now be put on, when the work of setting and adjusting the valves will be completed.—[Ed.]

Will Compressed Air Hurt Steam Boilers?

EDITOR THE PRACTICAL ENGINEER:

We have in our employ a night watchman who has had the handling of the boilers for over 37 years. He says that on a recent occasion he came on duty at 6 P. M. and found the boilers blowing at safety valves and the feed pumps running from an empty hot well, and he claims that there was great danger from compressing the air in the boilers. On being asked if he was sure that it was not steam that was blowing from the boiler, he became very indignent at his powers of discrimination being questioned as asked if I thought "he could not tell the difference between steam and air."

I would say that the suction pipe has an open end and at 5 P. M. the boiler showed 50 pounds gauge pressure, being set to blow-off at 60 pounds. This being a new feature to me, comments on the above are earnestly solicited. In conclusion, I must congratulate you on the many meritorious features contained in your bright and *practical* magazine.

Newtonville, Mass. ELAD.

As this has been a matter of discussion in the plant where it occurred, we would be pleased to hear from our readers on the subject.—[Ed.]

Why Will a Short Circuit Hurt a Constant Potential Machine and not a Constant Current Machine? Construction of Spark-Coils.

EDITOR THE PRACTICAL ENGINEER:

Will you please answer the following questions through your valuable paper, as they might be of interest to other readers?

(1). Why is it that an arc light dynamo may be short circuited without damaging it while an incandescent dynamo or railway generator is almost sure to burn out unless the short circuit is speedily removed?

(2). I wish to make a sparking coil for a gasoline engine sparker. My battery is 15 volts and I want to make 700 sparks per minute. Can you give me formula of how much wire I will have to use in primary and secondary coil; how much iron and what kind? I would like to have formula, as I could figure out my necessaries for any given coil, for any battery or any other sparking machine if the output is known.

Houston, Texas. R. L.

(1). The reason that a short circuit is capable of doing so much damage to an incandescent dynamo or railway generator and not to an arc-light dynamo is because an incandescent light dynamo and a railway generator are designed to give a constant voltage while an arc-light dynamo is designed to give a constant current.

That is, the heating of any circuit is directly proportional to the square of the current in that circuit. In a constant potential circuit, the effect of a short circuit is to give the current such a large value, due to the decrease in resistance owing to the short circuit, that its heating value is enormous and something must give way. To avoid this in practice, fuses are placed in the circuit so that they will be the first things to feel the effect of a rush of current through the circuit.

Since an arc-light dynamo always gives a constant current, the effect of putting in or taking out resistance in a circuit is to change the voltage and not the current, so that a short circuit does not cause a sudden rush of current when the resistance is reduced, the voltage at the dynamo being automatically regulated to suit the new conditions.

This regulation is effected in practice in two ways. The first method is to cause the machine to develop an electromotive force in excess of that required for the load and to

then collect an electro-motive force just sufficient to meet the load, which is done by shifting the brushes. The second method is to vary the magnetizing force in the field magnets just enough to put the required pressure on the line either by cutting out or short circuiting some of the field coils or by changing the current in them.

(2). The capacity of any induction coil, or the size of the spark required, depends upon the number of ampere turns in the coil and the amount of iron in the core. The product of the number of turns in the primary coil multiplied by the current passing through it gives the number of ampere turns available. The secondary coil is made up of many turns of fine wire, since in a spark it is the voltage that is required rather than the current.

A coil which will give a spark across a ½-inch space between the electrodes is made as follows: The iron core is made up of soft annealed wire, No. 20 wire gauge, 5¾ inches long, and ⅝ inch in diameter. After carefully insulating with shellac and paper and equipping it with wooden ends, wrap on two layers of No. 16 double cotton or silk covered copper wire. The secondary coil may be made of 8 ounces of double silk-covered copper wire, No. 36 gauge, each layer of which should be carefully insulated with paper and shellac, as should also the outer layer of the primary and the first layer of the secondary.

It is impossible to give a formula which will apply to every case, as the building of a spark coil is largely a matter of experience rather than of theory.—[Ed.]

Safe Pressure of a Water Tube Boiler.

EDITOR THE PRACTICAL ENGINEER:

Kindly oblige me by answering the following question: Is there any rule for ascertaining the safe working pressure of a water tube boiler?

Baltimore, Md. F. O. G.

As each type of water tube boiler is built upon a different design, it is impossible to give any rule for ascertaining the safe working pressure. In general, it may be stated that in a properly designed boiler, the tubes are considered to be the weakest part, so that a calculation of their bursting pressure would give the highest pressure at which it could run, and dividing this pressure by a factor of safety of 4 or 5 would give the safe working pressure. The tubes of this class of boilers are seldom more than four inches in diameter so that they can not only stand a high pressure but possess a large factor of safety as well.—[Ed.]

"Soft Patch" and Bursting Pressure of Boilers.

EDITOR THE PRACTICAL ENGINEER:

(1). What is a "soft patch" and why is it so called? Under what conditions and how is a soft patch put on a boiler?

(2). How do you find the bursting pressure of a boiler?

Washington, D. C. H. M. S.

(1). When a plate becomes badly oxidized or blistered, recourse is often had to the so-called "soft patch." A "soft patch" is made by bolting on a piece of boiler plate to the weakened surface and made tight by a cement of red lead and oil, or a mixture of red and white lead and oil mixed with iron borings and sal-ammoniac. The sal-ammoniac will promote the oxidation of the iron borings and the result is a hard stone like cement. It is called a "soft patch" to distinguish it from a "hard patch" which is a more permanent repair. When a "hard patch" is used, the defective metal is cut out and a new piece of boiler plate riveted on.

(2). There is no way of determining exactly what the bursting pressure of a boiler is, as it depends upon the type of boiler, thickness of the shell, and strength of the boiler plate. If, however, the tensile strength and thickness of the boiler shell are known, together with the diameter of the boiler and style of riveting, the pressure at which it will probably break can be calculated.

A formula which is used for calculating the strength of cylindrical shells in a direction parallel to the axis in terms of the bursting pressure is as follows:

$$P = \frac{T \times C}{D}$$

where P = bursting pressure in pounds per square inch; T = thickness of cylinder in inches; D = diameter of shell in feet and C = a constant which depends upon the material used in the boiler and the efficiency of the riveted joint. For wrought iron boilers, C = 4388 for single riveting and 5488 for double riveting; for mild steel boilers, C = 6892 for single riveting and 8624 for double riveting. Since mild steel is now being used almost exclusively in the manufacture of boilers, the two latter constants are more generally used. From the above formula, the following bursting pressures have been obtained for boilers using mild steel:

BURSTING PRESSURES OF CYLINDRICAL BOILERS.

	5-16" Plates.		⅜" Plates.	
Diam. of Shell in inches.	Single Rivets.	Double Rivets.	Single Rivets.	Double Rivets.
36	718	897	861	1076
39	662	827	794	992
42	615	769	738	923
45	574	718	689	861
48	538	672	646	808
51	507	636	608	760
54	473	581	568	710
57	443	554	532	665
60	430	538	516	645
63	410	513	492	615
66	391	489	469	587
69	374	467	449	561
72	359	449	431	539
75	344	430	413	516
78	331	414	397	496
81	319	400	383	479
84		388	369	461
87			356	445
90				430

The above pressures are those which are liable to break the boiler longitudinally, the pressure requiring to burst it transversely being twice as great. It must not, however, be concluded from this that a cylindrical boiler is more liable to burst from longitudinal than from transverse weakness. Many explosions have occurred from the latter source which have been due to the weakening of certain parts by the wear and tear on the boiler.—[Ed.]

Why Does Babbitt Break in Crank Strap?

EDITOR THE PRACTICAL ENGINEER:

I should like to ask you a question through your paper about a Westinghouse engine I am running. The babbitt keeps breaking in the right hand crank strap and I have done everything for it that I can think of. What do you suggest?

Proctorsville, Vt. B. A. W.

It is very probable that the cause of this trouble is due to the fact that the motion of the connecting rod is not at right angles to the centre line of the shaft. The effect of this would be to pinch the bearing at a certain portion of the revolution, especially if the boxes were a tight fit, which would result in breaking the babbitt.

This could happen by either the crank shaft or connecting rod wearing out of line. In this type of engine, the piston, which is of the trunk type, acts as the cross head, the connecting rod being fastened to a wrist pin in the hollow of piston on which it revolves. There is no means of adjustment at this point, a new bushing being put in when there is much wear at the joint. Neither is the strap nor are the boxes on the crank pin end adjustable, any lost motion being taken up by inserting shims between the top of the box and the square end of the connecting rod.

It is usual in practice to allow this joint to work somewhat loosely, as each cylinder is single acting, and if there is any wearing out of line this lost motion will prevent any damage to the boxes. We would therefore suggest that this joint be loosened and if that does not remedy the evil, see that there is no lost motion at the wrist pin so that the boxes cannot bind on the sides against the crank shaft. If this does not remedy the trouble, it is probable that there is some wear in the cylinder or the shaft is out of line.—[Ed.]

Receiver Pressure.

EDITOR THE PRACTICAL ENGINEER:

I would like to have your opinion about the running of receiver pressure on low-pressure cylinder of compound engine. When steam is low and high-pressure cylinder valves riding, whether to let the receiving pressure come down and ride low pressure or let low pressure cut off? Please let me know in next issue.

St. Joseph, Mo. T. G. Z.

It would be better to cut off the steam in the high-pressure cylinder and let the receiver pressure take care of itself. The economy of the engine depends upon the cut off in the high-pressure cylinder and it would be very wasteful to let the high-pressure valves ride.—[Ed.]

Groaning in Pumps.

EDITOR THE PRACTICAL ENGINEER:

Kindly give some causes and cures for groaning in pumps. How do you set valves on a compound duplex pump where high-pressure cylinder has 3 ports and low-pressure cylinder has 5 ports?

Chicago, Ill. W. A. F.

The groaning in pumps is usually caused by want of proper lubrication or too tight packing. Whenever there is a groan it means lost work. Examine the packing in both cylinders and in the stuffing boxes. It sometimes happens that the piston packing on the water end will swell and cause the piston to hug the cylinders very tightly so that it can be moved only with difficulty. In that case take off the head of the water cylinder, remove the follower from the piston and examine the packing. If too solid, loosen down the segments a little and pack more loosely.

The valves of each cylinder are set in the same manner as in a simple pump. The valves of both cylinders have the same travel and neither the high nor low-pressure valves have lap or lead, the ports and exhaust ports being wide open throughout the entire stroke.—[Ed.]

Hot Water Heating Systems. Commercial Horse Power.

EDITOR THE PRACTICAL ENGINEER:

(1). Suppose I have a hot water heating boiler; how hot can I heat the water? Of course, we all know 212 degrees is the limit and then we get steam. I have been told that in some plants the water is heated to 220 degrees. Now is it water or is it steam? As everything is full of water, there is no room for steam that I can see, but it seems to me there must be some steam or vapor somewhere, or is there no limit to heating the water in a hot water boiler?

(2). What is a commercial horse power?

Boston, Mass. F. H. R.

(1). The temperature to which the water in a hot water system can be heated depends upon the pressure of the system. If the system is open to the atmosphere, 212 degrees is the maximum temperature that can be obtained but if a safety valve be put on the system so as to obtain a pressure greater than that of the atmosphere, as is often done, then the temperature at which the water boils will be increased. In any case, if the expansion tank is not entirely filled with water (which it should not be) the upper portion of the tank will be filled with steam and vapor which creates the pressure and which if not relieved maintains it and increases the boiling point of the water above 212 degrees. A temperature of 220 degrees corresponds to a pressure of 2.5 pounds above the atmosphere.

(2). A commercial horse power is the rating given to boilers, engines, or other apparatus by the builders of the same. Whether a piece of apparatus gives out the horse power at which it is rated depends upon many variable conditions.—[Ed.]

A Disastrous Boiler Explosion.

One of the most disastrous boiler explosions that has taken place in the last decade occurred on the morning of March 20th, when the large shoe factory of R. B. Grover & Co., located at Brockton, Mass., was entirely destroyed, and about 75 employees killed as a result of the explosion of a 150 horse power boiler.

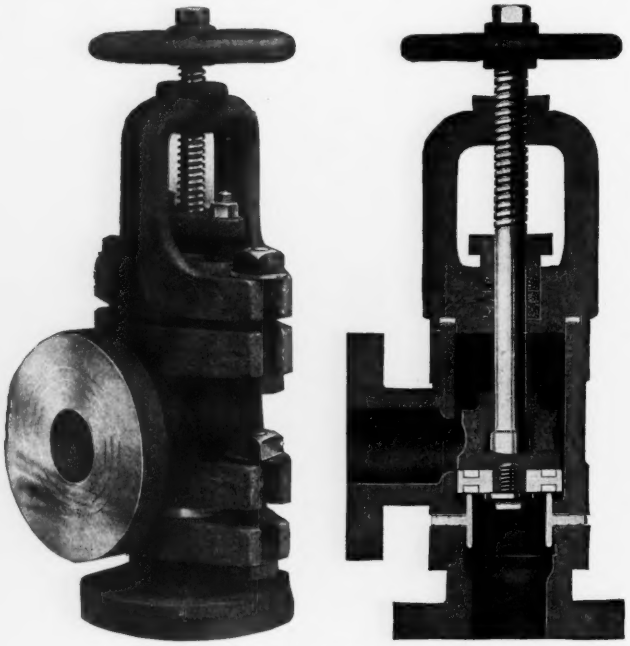
The boiler house was located in the angle of an L-shaped factory, which was a five story wood building 250 by 90 feet. When the boiler exploded it ripped the long portion of the building in two, killing many on its way. After cutting through the factory it knocked the top off of the house occupied by Engineer Rockwell, after which it struck another house farther along, which stopped its flight.

Scenes of horror followed the wrenching apart of the factory building. The three upper floors, weighted as they were with heavy machinery, collapsed with a crash and then almost instantly caught fire. As a result, many were killed or burnt to death; among these was engineer David W. Rockwell. Up to the present time of writing fifty-four bodies have been recovered from the ruins.

It is said that the boiler was comparatively new and that the explosion was not caused from low water but rather from a crack in the lap seam. It was regularly inspected and equipped with all the necessary appliances.

Cadman's Indestructible Blow-off Valve.

The conditions under which blow-off valves must operate are such that the seats undergo erosion caused by the rapidly moving dirty water when the valve is open and when the valve is closed any sediment or scale left on the seat or disc tends also to make the valve seat uneven. The effect of these things is



Cadman's Indestructible Blow-off Valve

to cause the valve to leak and it is a well-known fact that when once a valve begins to leak, it often grows worse steadily and sometimes very rapidly. Aside from the fact that a leaky blow-off valve always means loss in economy, in some cases it may produce results which might endanger the boiler. Any blow-off valve which can easily be repaired when it arrives in this condition should appeal at once to those who have trouble with leaky valves.

The valve shown in the accompanying illustrations has been designed to overcome these difficulties by making it possible to repair the valve with the least amount of trouble and delay. The valve seat and disc are both reversible so that repairs can be made by simply turning the disc or seat, or both, upside down. The valve seat is made with well rounded edges and the face of the disc is provided with a ring of comparatively soft metal, which is readily replaced.

When the valve is found leaking and there is not much time for repairs, the side bolts on the valve are removed, which allows the valve to come apart. By simply reversing the seat and disc, entirely new surfaces are obtained and by bolting the sections together again, a practically new valve is obtained.

When the boiler is shut down for any length of time, and it is desirable to repair the valve, the seat and disc can be removed and a new ring of soft metal put in the disc and the seat turned up in the lathe, restoring them to their original condition. Any of these repairs can be made without removing the body of the valve from its position.

The valve is therefore called indestructible since the parts subjected to wear can be used over and over again and when it is necessary to replace them, they can be renewed at very little expense. The manufacturers of this valve are the A. W. Cadman Mfg. Co., 2824 Smallman St., Pittsburg, Pa.

—o—

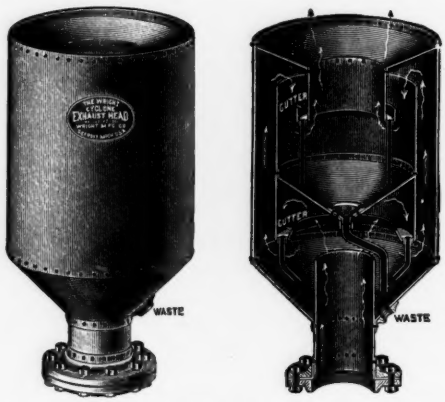
Wright "Cyclone" Exhaust Head.

The season is at hand when many plants will need exhaust heads, particularly if the buildings are to be painted or the roofs put in repair, and an exhaust head is wanted to prevent further damage by the spraying of oil and water from the exhaust pipe. Almost everyone has seen buildings whose walls show dirty streaks and patches, the result of a continuous discharge of oily spray from the exhaust steam, and the impression is almost always that such plants are not well kept up. Sometimes this discharge spoils the appearance of a painted sign and when permitted to accumulate on a roof, the oil rapidly gathers filth and the roofing material undergoes constant decay. In still other instances the chief objection to a spraying exhaust pipe is the annoyance it causes to people passing underneath. Injury to clothing on this account has even been the cause of several lawsuits.

It is to avoid the extra expense for painting and roofing repairs, and to put an end to the annoyance above stated that exhaust heads are being more widely adopted.

We illustrate herewith the construction of the Wright "Cyclone" Exhaust Head, which is manufactured by the Wright Manufacturing Co., 72 Woodbridge St., Detroit, Mich. Its operation is plainly shown by the sectional view, from which it will be seen that the exhaust steam, after leaving the exhaust pipe is impinged against an inverted cone and is then deflected outward against the sides of the inner shell, where the oil and condensation adhere and drip into the gutter, to be carried below the flow of steam by the drip pipes.

The steam after being deflected by the cone, passes up between the outer and inner shells (follow the course of the arrows shown in the cut) and is again impinged against another



Exterior and Sectional View of the Wright "Cyclone" Exhaust Head.

inverted cone forming the top. The steam then turns and passes down between the inner shell and the outlet pipe, the remaining condensation being removed from the steam by its contact with the under side of the top cone and the outlet pipe. This condensation is then collected by means of the gutter surrounding the outlet pipe and the five drip pipes lead it below the flow of steam to the waste pipe.

In the construction of this exhaust head, the possibility of

back pressure being caused upon the engine is entirely avoided. Reference to the sectional view will show an absence of cramped passages and the outlet being several times larger than the inlet allows an easy flow of steam through it.

Extra heavy galvanized plate is employed throughout the construction of the exhaust head, making it practically indestructible. The drip pipes from the gutters and cone are of galvanized iron, and the connections being made of brass, prevent rusting at points where repairs would be impossible. The waste flange is also heavy brass and is strongly riveted and soldered to the shell. A heavy coating of rust-proof paint protects all exposed parts.

Further particulars as to the extremely durable construction of the "Cyclone" exhaust head, its efficiency under all conditions in extracting all moisture and oil from the exhaust steam, also muffling the noise of the exhaust, will be furnished by the Wright Manufacturing Co., 72 Woodbridge St., Detroit, Mich., who are also manufacturers of the well-known Wright Emergency High Pressure and Victor Low Pressure Steam Ttraps and Wright Improved Safety Water Columns.

New Books.

Cyclopedia of Applied Electricity. Published in five volumes, containing 2500 pages and 3000 illustrations. Bound in three-quarters red leather. List price, $30.00; special introductory price, $18.00. Published by the American School of Correspondence at the Armour Institute of Technology, Chicago.

These books are a very comprehensive work on the subject of electricity and its practical applications and have been designed as a practical guide for engineers, telephone and telegraph operators, engineering students and all others interested in the practical applications of electricity.

It is addressed particularly to students and to the thousands of practical workers in the electrical field and for this reason higher mathematics have been entirely omitted and the subject matter explained in simple language in connection with a large number of diagrams prepared especially for the text. The latest developments of electricity are described by acknowledged authorities and the volumes contain many illustrations of apparatus made by the prominent electrical companies for the purpose of acquainting the reader with the types of apparatus used in current engineering practice.

The elements of electricity and magnetism are described in Part I, together with the principles of the electric current, electrical measurements, electric wiring, the telegraph, wireless telegraph, telautograph, insulators and electric welding. Part II takes up the theory of dynamo electric machinery, direct-current dynamos and motors, types of dynamo electric machinery, electric motors in machine shop service and storage batteries. Part III takes up the subjects of electric lighting in general, shop lighting, electric railways, management of dynamo-electric machinery and power stations. Part IV is devoted to alternating currents and power transmission, while Part V contains a complete description of telephone instruments, lines, exchanges, batteries, systems, maintenance and wireless telephony.

As these books have been designed as text books, a great deal of attention has been given to practical examples and each volume is supplemented with a list of review questions by means of which the reader can test for himself the knowledge he has acquired of the subjects treated. The usefulness of the cyclopedia as a reference book is augmented by the addition of a subject index contained in the fifth volume.

The practical value of the work as a whole is the outcome of the various electrical courses which have been used by the American School of Correspondence in teaching a great number of electricians and as a reference book it should be very useful to designers, constructors, and operators of electrical machinery, as it covers every department of electricity in the five books.

The Study of Electricity for Beginners, Electrical Circuits and Diagrams and Model Steam Turbines are the names of three books which have recently been issued by Spon and Chamberlain, New York, in connection with their popular 25 cent series.

These books are very elementary in their character and have been written especially for the practical man who does not wish, or, who has not the time for, deep scientific works.

The Study of Electricity includes the laws of electric current generation and flow, Ohm's law, magnetism, induction, principles of dynamos and motors, wiring and simple electrical calculation. Electrical Circuits and Diagrams gives a number of diagrams for installing annunciators, alarms, bells, telephones, wiring circuits, gas engine igniters, armature windings and dynamos and motors. Model Steam Turbines is a book which deals with the action of the steam turbine and explains how to design and build them.

The Steam Turbine, by Dr. A. Stodala and Prof. L. C. Lowenstein. Size, 6½ x 9½. 435 pages and 241 illustrations. D. Van Nostrand Co., New York. Price, $4.50.

The steam turbine has recently become such an important factor in steam engineering that many investigators and inventors have turned their efforts to solving the problem of its action. Perhaps the foremost man in the study of the action of steam through a nozzle, as applied to the turbine, is Dr. Stodala, Professor at the University of Zurich, who is looked upon as an authority on the subject. His book has been translated by Prof. Lowenstein, because there is no book which treats of the turbine so exhaustively from a purely scientific standpoint, and for this reason it is now considered the standard book on the subject.

It is intensely mathematical throughout, involving all the usual methods of differentiation and integration as used in the theory of thermodynamics. Among the many things treated in the book may be mentioned the elementary theory of the steam turbine, theory of the steam turbine thermodynamically considered, construction of the most important turbine parts and the different types of steam turbine.

This book should prove most helpful to designers, technically educated engineers, and to students of technical schools.

The Art of Generating Gear Teeth, by Howard A. Coombs. D. Van Nostrand Company, New York. Price, 50 cents.

This book is useful for machinists and draughtsmen or for any one interested in the art of generating gear teeth. It includes the theory of tooth curves, the formation of gear teeth and the different types of generating machines. It is well illustrated with 37 line drawings relating to the principles of gear teeth curves and machines and methods for cutting them.

The Steam Engine, by Robert C. H. Heck. Size, 6½ x 9½. 400 pages and 190 illustrations. D. Van Nostrand Co., New York. Price, $3.50.

As a text book for engineering colleges, this book should fill a long-felt want, as it combines the thermodynamics and mechanics of the steam engine under one cover. It is the object of this book to set forth clearly the fundamental principles of the steam engine, to give a broad dscription of constructive practice, to explain fully the working of the machine and to show how to find its efficiency in performance.

It is very well written but it is assumed that the reader must have a good preparation in mathematics, physics and mechanics. The primary theory of the heat-engine with a perfect gas is first built up, from the simplest statements to the establishment of the ideal thermodynamic process in the Carnot cycle. Then the properties of steam are described and illustrated; first, in the Carnot cycle, then in the less perfect operations which approach more closely to actual conditions.

The working theory of steam jet apparatus is then taken up and the principles involved as applied to the flow of steam in pipes, the steam calorimeter, injector and steam blower. A study of the mechanics of the steam engine is taken up in the final chapter.

All of the chapters are well illustrated and graphical methods are used throughout in preference to algebraic formula. The book also contains a number of useful tables.

TRADE NOTES

EDITED BY THE ADVERTISING MANAGER

An automatic boiler skimmer is an interesting device; not that it's new, for the principle upon which it operates is as old as the hills; but because of its application and the manner by which it accomplishes the desired results; namely, the removal of mud, sediment and scale-forming impurities from the water. In this connection, the "Buckeye" automatic skimmer has achieved some remarkable results of late, one of which is mentioned in a letter which is reproduced in an advertisement on page 58 of this issue; and scores of similar letters are constantly reaching the builders of this apparatus. The reason the Buckeye machine is meeting with such success is because it is entirely automatic, requiring practically no attention after it is installed. If you have never seen one, you should write for illustrated catalogue, which shows it applied to various types of boilers. Address, The Buckeye Boiler Skimmer Co., Toledo, Ohio.

No engineer's education is complete until he is familiar with the complete line of Foster valves, their construction, operation and many peculiar advantages, all of which would require a dozen pages of this journal to describe comprehensively. Even the catalogue issued by the manufacturers does not describe them as their merits deserve, but it contains some good sectional illustrations and enough information to make it indispensable to any engineer who is managing, or who ever expects to manage, a modern power plant. We presume that a copy of this interesting little catalogue will be sent to any reader of "The Practical Engineer" upon request. Address, Foster Engineering Co., Newark, N. J.

The handsomest new catalogue that has come to our notice during the past month, and one in which the various specialties shown give evidence of a high degree of mechanical genius and, in some cases, genuine originality, is that of The Williams Gauge Co., Fourth Avenue and Try Streets, Pittsburg, Pa. It is printed on fine coated paper and the illustration are excellent specimens of the engravers' art. In addition to illustrations of many notable industrial plants, this catalogue describes the Williams' complete line of steam specialties, all of which are illustrated in detail. A copy of this handsome catalogue will be sent to any engineer interested.

J. E. Lonergan and Co., 211 Race St., Philadelphia, publish an interesting catalogue describing lines of brass goods and engine room specialties, including oil cups and general oiling devices, pop safety and water relief valves, steam gauges, whistles, injectors, damper regulators and low water alarms. A copy will be mailed to any reader of "The Practical Engineer" upon request.

Oleaqua Hydraulic Compound is a neutral oleaginous mixture for use in hydraulic elevator systems. It neutralizes hard or acid water, prevents pitting, rust or oxidation, preserves metal generally, saves joints and connections and greatly improves the elevator service. The manufacturers of this new material offer to send a keg of it to any steam user, freight prepaid, with the distinct understanding that if the men in charge of tha elevator cars fail to notice an improvement in the running of same within one week after commencing to use the compound, due to better lubrication of the valves and pistons, they will make no charge whatever. Write for circular to O. F. Zurn, 25 South Fifth St., Philadelphia, Pa.

The American Water Softener Co., 1002 Mutual Life Building, Philadelphia, have received a letter from the Heine Safety Boiler Co., speaking in very complimentary terms of the American Water Softening machine installed at their Phoenixville plant several months ago.

Grapho is a compound of selected materials and the best and finest Graphite, compounded in such proportions that the Graphite will mix thoroughly and evenly with all kinds of lubricating oils and remain in suspension for a long time. Mixed with cylinder oils it feeds evenly and perfectly through all lubricators (Force feed and Sight feed), the Graphite being fed in constantly with the oil and does not settle and clog the openings of the lubricator. This is just the thing that engineers have been wanting for a long time. Everything comes to him who waits and it's here at last. Write for circular and free sample to Grapho M'f'g Co., Corner Frank and Commercial Sts., Rochester, N. Y.

You talk to our engineer, he buy only what he recommends.
Master is not making a mistake this time
HIS MASTER'S VOICE
TO OIL SALESMAN.
A.E. Rhodes

The Turney Drier Co. have associated with the Henry Vogt Machine Co., Louisville, Ky., and moved their office and works to the Henry Vogt Machine Co.'s plant and elected new officers: Adam Vogt, President; Henry Vogt, Vice-President, and Albert H. Vogt, Secretary and Treasurer. They are now installing the latest improved machinery to manufacture the direct heat and steam driers, roller and filter presses, and have secured additional capital to carry on the business.

The Stillman-Carmichael Co., 19 Pearl St., Boston, Mass., will continue the business heretofore conducted by G. G. Stillman, now deceased. They will continue the manufacture of the Improved Damper Regulators built under the Carmichael patents and will carry a full line of supplies and repair parts for these regulators.

The Philadelphia offices of the Buffalo Forge Co. are now at 1022 Land Title Building, having removed there during the past month.

The Mickle-Milnor Engineering Co., 820 Drexel Bldg., Philadelphia, have just been appointed as representatives of the C. & G. Cooper Co., builders of Corliss engines.

The April number of "Graphite," issued by the Joseph Dixon Crucible Co., Jersey City, N. J., will contain many illustrations of notable buildings and bridges, as well as seasonable talks on paint and painting. Engineers who are interested in paint for stacks or other purposes should write for a copy, which will be sent them gratis. Address as above.

The Emergency Pipe Clamp for repairing splits and leaks in pipes, which is being placed on the market by the manufacturers, James McCrea & Co., Chicago, is certainly filling a long-felt want, as is shown by the number of orders they are receiving for them. There is hardly a jobber in the country that is not sending in his order for a complete stock from ½ inch to 4 inches.

Mr. A. C. Lippincott, General Manager of the Indicator Instruction Company and the Lippincott Steam Specialty and Supply Co., states that he will send to those who address him at 95 Green St., Newark, N. J., full particulars of the Instruction Course in indicator work, with which the indicator is included, free of all further expense, and also a set of folding indicator scales in a leatherette case. He will also send a nice catalogue of indicators, reducing wheels and planimeters, which he thinks is well worth the trouble of writing for.

There is one sure way to prevent mud and oil from getting into your boiler, and that is to filter the water with a Blackburn Smith patent feed-water filter and grease extractor. This filter is made specially for steam plants and is undoubtedly the best apparatus of the kind yet produced. It is built by Greacen-Derby Engineering Co., Perth Amboy, N. J. Write them for catalogue.

"Ever see a 'P. B. H.' quick closing water gauge?" "Sure, got them on our boilers." Well, that's what I thought, but if you happen to have a boiler that is not equipped with one it will pay you to get another before the glass breaks next time; it may save a lot of dam-

age or a bad burn. They are made by Paul B. Huyette, 1245 Betz Bldg., Philadelphia. Illustrated circular on request.

Salesmen who are acquainted with steam users in towns along the Mississippi, Missouri and Ohio rivers can hear of a good paying proposition by writing to J. L. Tillman, 527 Colburn St., Toledo, Ohio. Mr. Tillman also wishes to make arrangements with one or two good supply salesmen in other sections. Engineers who wish to act as local representatives for a good specialty on liberal commission basis should write at once, giving full particulars about themselves and stating how much time they wish to devote to the work.

We are advised by the Lagonda Mfg. Co., manufacturers of the well-known Weinland Tube Cleaners, Steam and Boiler Room Specialties, that they now have branch offices in the following places: Pittsburg, Iron Exchange Bldg., Robert Gregory, manager; Philadelphia, Builders' Exchange, Jas. V. Davidson, manager; New York, 123 Liberty St., C. A. Gillett, manager; St. Louis, 511 Missouri Trust Bldg., J. P. Maloy, manager. They also have selling arrangements at the following places: Chicago, The Chicago Engineer Supply Co., San Francisco and Los Angeles, Chas. C. Moore & Co.; Toledo, O., Hardy & Dischinger Co.; Kansas City, Mo., E. D. Hornbrook; Peoria, Ill., Kinsey & Mahler; Indianapolis, Ind., Hide, Leather & Belting Co.; London, Eng., Selig, Sonnenthal & Co.

JUST WHAT YOU NEED,

A New Book on Injectors. Their Construction Care and Management, 84 Pages, 45 Engravings, 61 Tables, By Frederick Keppy, M. E. I will send you a copy of this valuable Book on receipt of 25 cents in postage stamps.

F. KEPPY
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Hughes Smoke and Spark Preventer For Stationary Boilers

Patented March, 1902, in United States and Foreign Countries

Prevents smoke and sparks, whatever kind of coal is used.

Insures perfect combustion, consuming all gases, thereby securing highest economy possible.

Increases the capacity of any boiler, while saving labor and fuel.

Can be readily installed in all forms of boilers and boiler settings.

NO MOVING MECHANISM NO STEAM USED NO POWER USED

NO EXPERIMENT, it being in actual successful commercial use.

SIMPLE, therefore lower in cost than any other device for similar service.

SENSIBLE, therefore its method of operation is apparent to every one.

ECONOMICAL, therefore worthy of earnest consideration by prudent men.

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This information is given for the benefit of the trade, so that anything needed in this line can be furnished promptly, and at reduced transportation cost from any of these points.

The factory and general offices of the Company are at Springfield, O.

"A chain is no stronger than its weakest link," neither is a sentence easier than its hardest word, or a paragraph than its most difficult sentence. One word not understood makes the sense of the entire sentence in which it appears purely conjectural to the reader, and it may destroy for him the value of an entire chapter. If the International Correspondence Schools, of Scranton, Pa., had attempted to use textbooks loaded down with technical terms, they could never have succeeded in girdling the earth with students filled with a strong purpose of adding the essential elements of science to the practice of their occupations.

The International Correspondence Schools have had a wonderful growth, and their history is unique. About 15 years ago the Legislature of Pennsylvania passed laws requiring coal miners to pass strict mine examinations. Many of these men were capable of performing their duties, but how to pass the technical examinations became a serious problem. Mr. T. J. Foster, now President of the Schools, at that time editor of the *Colliery Engineer*, conceived the idea of training these men, in the theory of their work, by correspondence instruction. He prepared a Course in Coal Mining of the simplest language possible, but complete in every detail. The Course met with immediate approval and success.

To meet a demand for correspondence instruction from men and women in other occupations, the International Correspondence Schools were founded in 1891. The best experts obtainable were engaged to prepare the various Courses and direct the instruction. To-day the institution has over 175 Courses, and, in thirteen years, has enrolled over 700,000 students in all parts of the world.

The accounts of the rise of some of the I. C. S. students read like romance. Many of these experiences have been published in book form, and are exceedingly interesting. The book is entitled "1001 Stories of Success," and can be had for the asking if you mention "The Practical Engineer."

The Continental Chemical Co., 2923 North Broad St., Philadelphia, want engineers to write for their special boiler compound proposition; and while you are about it, just ask them to send you one of their interesting little booklets.

One of the handsomest damper regulator catalogues tnat has come to our notice is issued by W. P. Dennis, inventor and manufacturer of the Straight Line Damper Regulator, 635 Arch St., Philadelphia. Mr. Dennis will send a copy of his new catalogue to any reader interested.

John M. Watt's Sons have removed to 232 North Third St., Philadelphia.

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A new preparation for enriching oils.
Will suspend in oil.
No more Hot Journals.
Engineers who have tried same claim it to be the best yet.
SEND FOR SAMPLE
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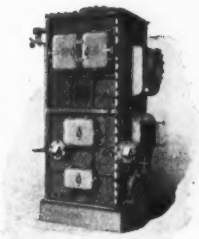

Feed Water Purification

Our system of feed water purification provides for saving and utilizing all condensed exhaust that is worth saving, and for treating the raw water required for supplementing this condensation by chemical means and with simple mechanical aids, thereby preventing the formation of hard scale in the boilers and at the same time utilizing any free acids present in the water which might cause corrosion. The System also utilizes exhaust steam to the fullest extent for heating the feed supply.

It is a commercially practicable method for securing the desired results with the minimum expenditure for the cost of the apparatus, for the chemicals used, and for the attention required. It is practicable, comprehensive and thorough. Your engineer or fireman can operate it without interfering with his other duties.

That it is good and well worth your while to investigate is evidenced by the fact that we have completed installations of these Systems aggregating over 500,000 H. P.

Greater savings can be effected by keeping scale out of boilers than are possible through any changes that can be made in engines or boilers. Besides the cost of removing scale there are boiler repairs and new boilers, shut-downs, tremendous extra coal consumption and loss of steaming power. Beyond question we can help you and the cost will be most reasonable. One plant that we have equipped aggregates 63,000 H. P.

Let us know when you are ready to go into the subject of purifying and heating your feed supply.

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